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THE DYNAMIC CONCEPT OF THORACIC TOPOGRAPHY

A CRITICAL REVIEW OF PRESENT DAY TEACHING OF VISCERAL ANATOMY*

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INTRODUCTION

BY GENERAL agreement of anatomists, "all topographical descriptions are framed on the anatomical convention that the body is in the erect position" (Cunningham[7]). This, in conjunction with a clearly defined attitude of the upper extremities, is referred to as "the anatomical position." "The cadaver may be placed on the table lying on its back, on its side, or on its face, but for descriptive purposes it is assumed to be standing erect in the anatomical position" (Grant[13]). For reasons of convenience the dissection of the viscera is customarily undertaken with the cadaver lying supine, and this is also the position in which the relation of the thoracic and abdominal organs to the surface features of the body is determined and described in anatomical texts. Yet in view of the previously quoted definition of the anatomical position, it is surprising that so few investigations on the location of the viscera have been undertaken with the cadaver in the upright position.

Taken by itself, the subject of topographical anatomy is of little educational value. Its importance lies in the fact that it furnishes information which is applicable to the study of the viscera in the clinical sciences. The establishment of normal standards for the size, shape and position of the organs in the living is a necessary prerequisite in the field of physical diagnosis and clinical medicine. It goes without saying that the study of the human cadaver by dissection is one of the most helpful methods in the exploration of the form and location of the human viscera, but the limitations of this approach in the field of topographic anatomy should be recognized and the findings corrected in the light of investigations in the living subject by means of roentgen studies. Even the textbooks of physical diagnosis, which concern themselves with the topography of the viscera in the living, employ mostly the time honored norms of conventional anatomy that are based on studies on cadavers.

Several investigators, foremost among

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them Moody and his co-workers[26,27] in this country and Barclay[2] in Britain, have reexamined the position and surface projection of the abdominal viscera by roentgenographic methods in the living. The results of their studies have shaken our established beliefs as to the site and relations of the abdominal organs. Particularly have they challenged the static concept of the position of the abdominal viscera as expressed in the teachings of Addison.[1] This author, whose work was published at the turn of the century and whose diagrams are still found in our anatomical texts, divides the abdominal region into a number of small squares and assigns to each organ a definite place in this scheme. In contrast, the authors who have approached the problem by means of roentgen studies in the living, have shown that "the normal abdominal viscera have no fixed shapes and no fixed positions, and that every description of them must be qualified by a statement of the conditions existing at the time of observation" (Barclay[2]). Where the results of these roentgenographic studies have been included in our teaching of anatomy, they are usually not sufficiently integrated with the conventional presentation of visceral anatomy, but rather are they offered as an appendix to the classical description of the position and relation of the organs. This makes it appear as if the difference in the findings were due to a change in method, i.e., from dissection to roentgenography, and not to a change in the object explored, namely, from the recumbent cadaver to the living subject in its varied posture. It goes without saying that roentgen investigations in the supine cadaver confirm the results arrived at by dissection.

With respect to the thoracic viscera the belief is usually held and set forth in anatomical texts that their shape and position are not subject to marked variations (Lubosch[22]). Again, as in the abdomen, conditions found in the recumbent cadaver are presented as the norm, also for clinical purposes. Little or no attention is paid to temporary physiologic alterations in the site and configuration of the thoracic organs and to constitutional variations from individual to individual. Surprisingly few studies have concerned themselves with the surface relationship of the thoracic viscera as revealed by roentgen study in the living. The investigations which have been undertaken so far have challenged our established opinions on visceral topography of the thorax and have proved that—as in the abdomen—the location of the viscera frequently does not coincide with the position assigned to them from studies on cadavers.

REASONS FOR DISCREPANCIES IN RESULTS OBTAINED BY DISSECTION AND BY ROENTGENOGRAPHY

As to the results obtained in the living by means of roentgen studies and in the dissected cadaver, complete conformity can hardly be expected for the following reasons:

1. In the cadaver all muscles including the diaphragm are either in a state of complete relaxation or of abnormal rigidity due to rigor mortis, there being some displacement of the viscera in either case. The heart muscle likewise changes its configuration considerably after death. Postmortem contraction brings about a decrease in the transverse diameter of the heart which makes it appear more pointed (Roesler[33]). This is followed by secondary dilatation. The final shape and size of the heart in the dissecting room depends on the interval that has elapsed between the moment of death and the embalming of the body. The condition of the heart muscle at the time of death and the cause of death are also of influence, since marked myocardial degeneration or wasting diseases preclude pronounced cardiac rigor (Roesler).

2. The cadaver is explored in the supine position with the thorax in a state of extreme expiration, the viscera being displaced dorsally and craniad.

3. The position of the thoracic viscera in the cadaver is investigated usually after the body cavities have been opened with

resulting non-physiologic equalization of pressure.

4. The connective tissue as well as the alveolar spaces of the lung is edematous due to diffusion of embalming fluid.

5. The veins are for the most part desanguinated and the large arteries of the mediastinum decreased in length and width due to the absence of the dilating force of the blood pressure (Roesler).

All these factors work together to produce marked changes in the shape and position of the thoracic viscera in the cadaver. In contrast, these pitfalls are avoided in the roentgenographic exploration of the living, a study which can often be done with the subject in the upright, i.e., the anatomical position and which in the hands of the experienced observer is capable of furnishing valuable information on visceral topography. This shall be exemplified by a comparison of the topographic anatomy of the tracheal bifurcation, of the heart, and of the posterior pulmonary and pleural boundaries as revealed by roentgenography of the living and by dissection in the cadaver.

TOPOGRAPHIC ANATOMY OF THE TRACHEAL BIFURCATION

The bifurcation of the trachea is customarily placed at the level of the intervertebral disc between the fourth and fifth thoracic vertebra or at the level of the upper border of the fifth thoracic vertebra, corresponding to the sternal angle between manubrium and body of the sternum (Fig. 1*d*). But roentgenography of the upright adult subject usually shows the bifurcation considerably lower, commonly at the level of the sixth thoracic vertebra (Bársony and Wald,[5] Köhler[16]). It may be found as low as the seventh thoracic vertebra (Kreuzfuchs,[18] Fig. 1*c*). The discrepancy can readily be explained by the general lowering of all viscera in the upright position which is caused by gravitational pull. Roentgenograms in the supine position usually show the bifurcation at the level of the fourth or fifth thoracic vertebra. Engel has studied the position of the bifurcation at different ages by means of roentgenograms (Fig. 1, *a* and *b*). According to this author the bifurcation is located at the following levels:

> During the first year—at the level of the third or fourth thoracic vertebra
> From the second to the sixth year—at the level of the fourth or fifth thoracic vertebra
> From the seventh to the twelfth year—at the level of the fifth or sixth thoracic vertebra.

Thus the bifurcation of the trachea participates in the descent of the viscera which is a general phenomenon that takes place during the life span of the individual, and which will be referred to also in connection with the heart and the inferior boundaries of the lungs. Anatomical texts frequently speak of the bifurcation of the trachea as being fixed in position (Morris,[28] Cunningham[7]), yet—disregarding the contradiction—quote the roentgen studies by Macklin,[23] which prove a respiratory shift in the location of the bifurcation.

TOPOGRAPHIC ANATOMY OF THE HEART

The relationship of the roentgen silhouette of the heart to the anterior thoracic wall in the living has not been investigated sufficiently to serve as a foundation for our teaching of cardiac topography or as a clinical standard in physical diagnosis. Anatomical texts as well as treatises on physical diagnosis commonly base their presentation of this important subject on studies of cadavers. Thus, to give one example, Morris'[28] discussion of the topographic anatomy of the heart rests on LeWald's roentgen studies "of a formalin preparation of the anterior thoracic wall with the heart, pericardium, and diaphragm in situ." But the roentgenogram of this preparation (Morris' Fig. 488, 10th edition) reveals the cadaveric state of the thorax and the diaphragm and can therefore hardly be used as a standard for the living. For reasons previously discussed the surface projection of the heart of the cadaver differs considerably from the surface relationship of this organ in the living, par-

ticularly if we presuppose that the body is in the anatomical, i.e., upright position.

Why then, we may ask ourselves, has not the roentgenographic study of the living in the upright position, which avoids all these pitfalls, been used as the main source of information on the topography of the heart? The answer lies in the difficulties of this undertaking. The anterior thoracic wall, which serves as the plane of projection, does not represent a constant, but is subject to numerous variations in its configuration. In addition, it is not clearly outlined on the roentgenogram since the important landmarks of sternum and costal cartilages are hardly visualized. The upper and lower borders of the heart are not depicted directly on the roentgenogram but have to be drawn somewhat arbitrarily by connecting the right and left superior and inferior terminal points of the lateral contours. But the main difficulty is caused by the fact that, as a result of physiological alterations, the heart is subject to continu-

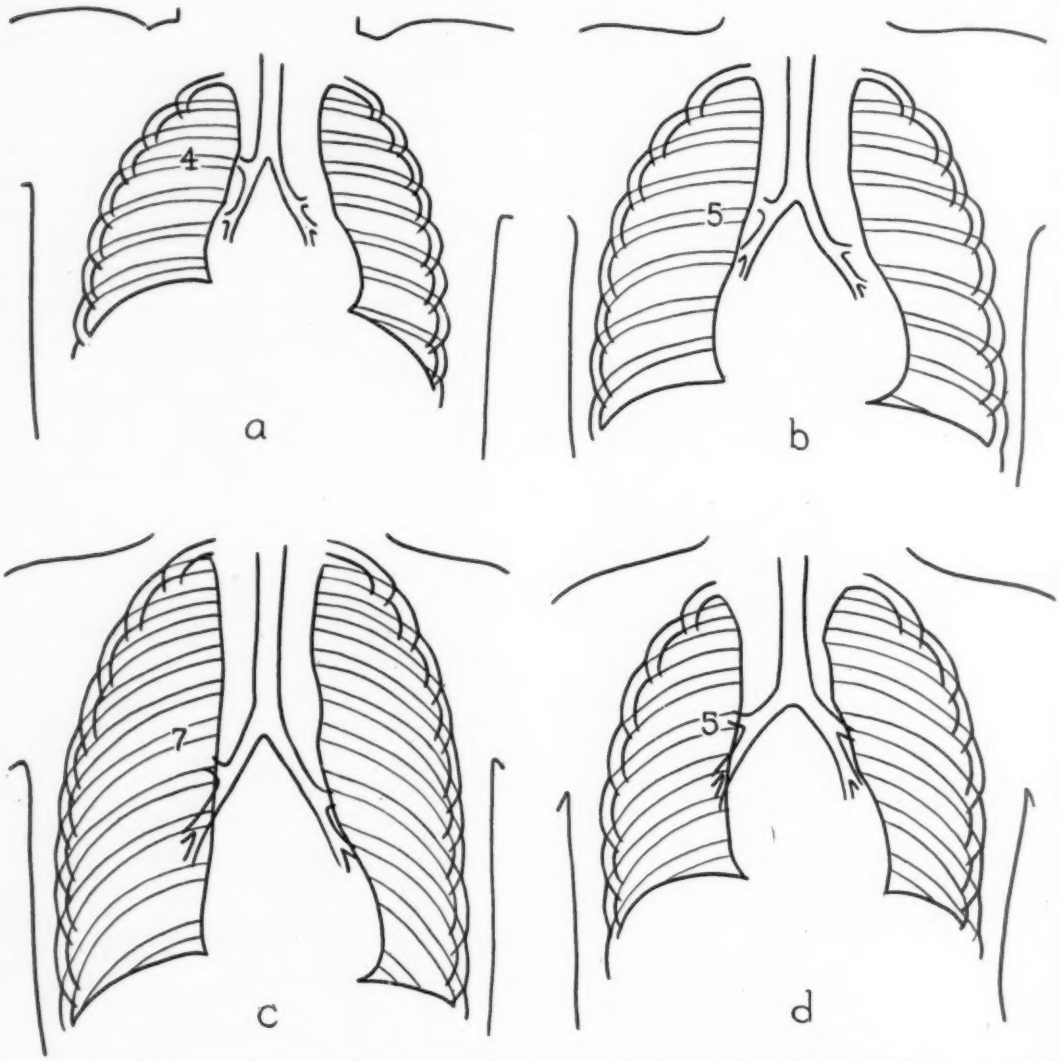


Fig. 1. The variable position of the tracheal bifurcation: *a*, in the newborn (after Engel[11]); *b*, in a child, three years old (after Engel[11]); *c*, in the upright adult (after Kreuzfuchs[18]); *d*, in the adult cadaver (after Cunningham[7]).

ous changes in its absolute and relative dimensions and therefore also in its surface relationship. Furthermore, there are great normal variations in the size, shape and position of the heart from individual to individual as an expression of differences in body build, age, sex, weight, height, and muscular development.*

FACTORS INFLUENCING CARDIAC CONFIGURATION

A. Position of the Diaphragm

Variation in the position of the diaphragm is the greatest single factor responsible for marked differences in cardiac configuration and its surface projection. This is understandable if one realizes that the heart is firmly attached to the central tendon of the diaphragm by means of the pericardium and that it must follow all diaphragmatic excursions. Consequently a lowering of the diaphragm, e.g., in inspiration, is accompanied by a descent of the heart. At the same time the heart undergoes a rotation around its longitudinal axis so that its apex is turned forward and medially. The right margin, being relatively fixed in its position by the attachments of the two venae cavae, takes part in these movements only to a lesser degree (Fig. 2). The reverse movement occurs in expiration.

The influence of diaphragmatic position on cardiac dimensions can best be studied by comparing the roentgen silhouettes in the two extremes of diaphragmatic location. Diagram *a* of Figure 3 depicts a thorax with a markedly elevated diaphragm. Its dome is approximately at the level of the posterior portion of the eighth rib. The heart appears short and wide, somewhat comparable to a "lying egg." The waist of the heart, i.e., the constriction between the vascular and cardiac portions of the silhouette is quite pronounced, hence the flare below the waist is marked. Its transverse diameter and particularly *Ml* are large, *Ml* being more than twice the

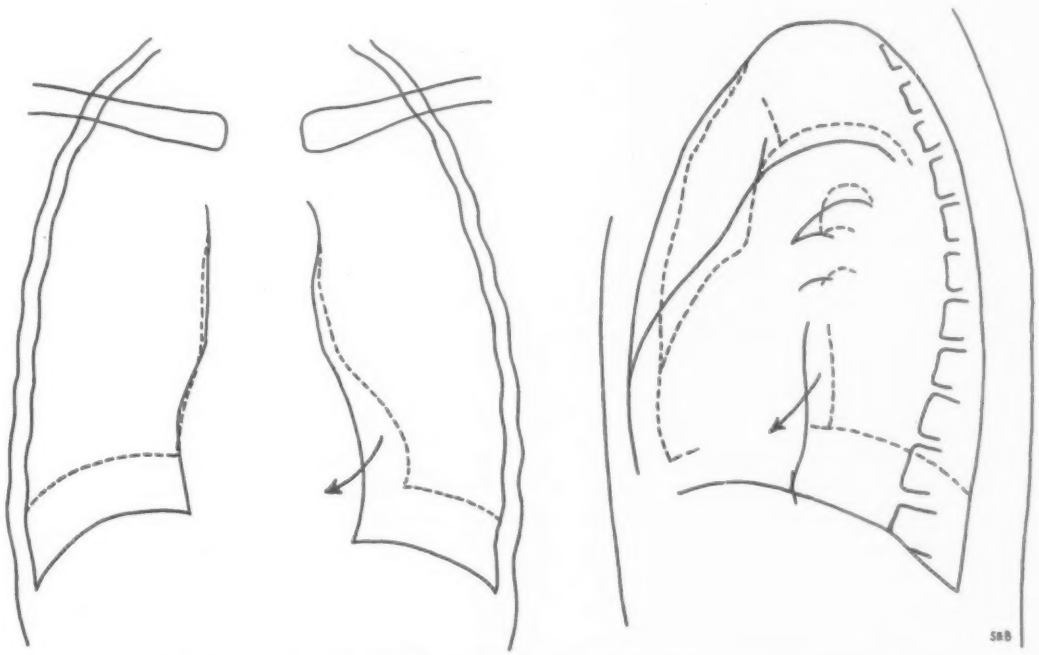


FIG. 2. Rotation of the heart in inspiration (posteroanterior and lateral views).

* The following roentgen-ray physiological discussions are based on the clinical experiences of the author and careful perusal of the literature, particularly of the monographs by Dietlen,[10] Roesler,[33] Groedel,[14] Zdansky[35] and Kurtz.[20]

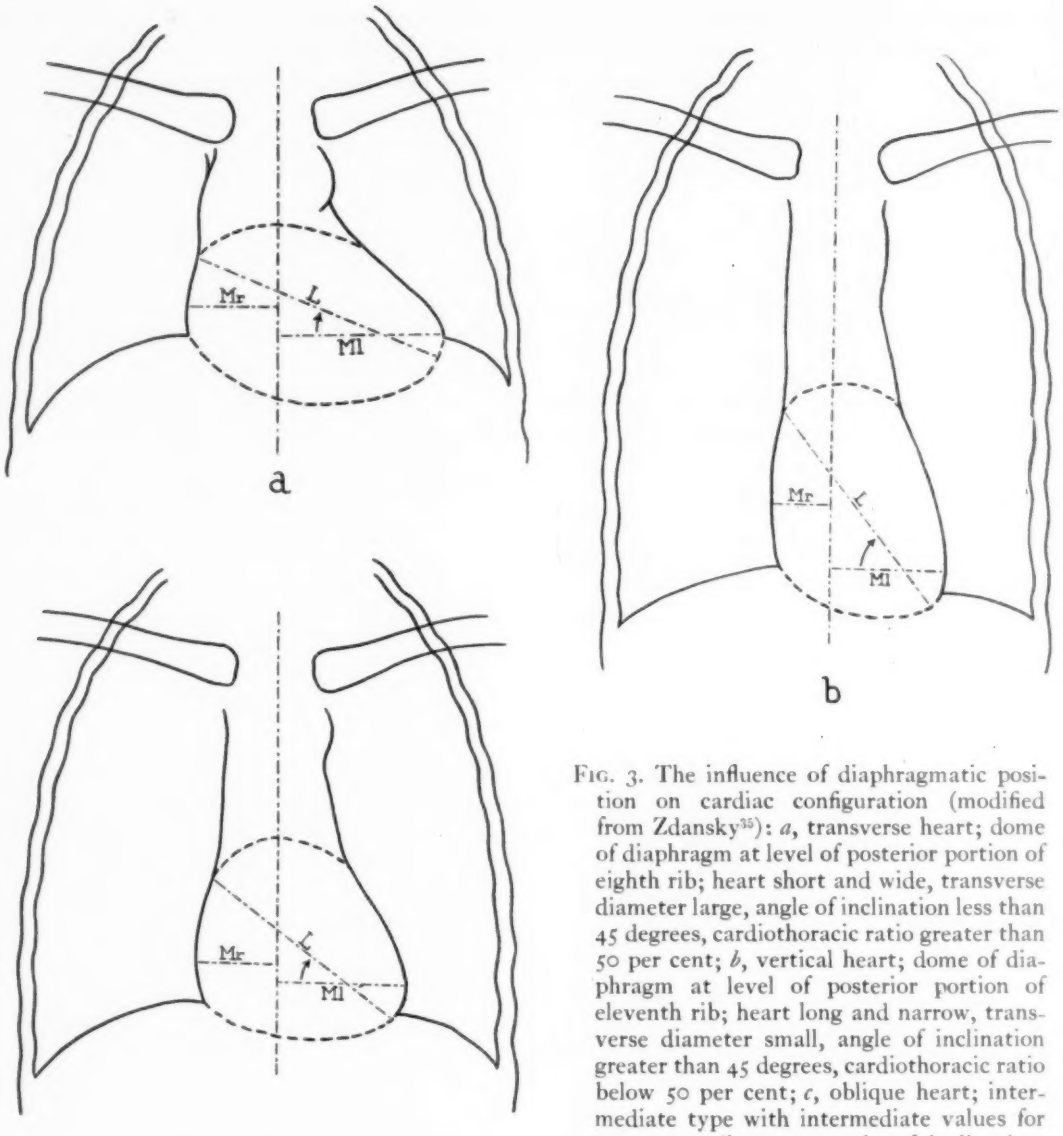


Fig. 3. The influence of diaphragmatic position on cardiac configuration (modified from Zdansky[35]): *a*, transverse heart; dome of diaphragm at level of posterior portion of eighth rib; heart short and wide, transverse diameter large, angle of inclination less than 45 degrees, cardiothoracic ratio greater than 50 per cent; *b*, vertical heart; dome of diaphragm at level of posterior portion of eleventh rib; heart long and narrow, transverse diameter small, angle of inclination greater than 45 degrees, cardiothoracic ratio below 50 per cent; *c*, oblique heart; intermediate type with intermediate values for transverse diqmeter, angle of inclination, and cardiothoracic ratio.

length of *Mr*.* Its longitudinal diameter *L* approximates the horizontal which implies that the angle of inclination is small, less than 45 degrees, the cardiothoracic ratio is greater than 50 per cent, i.e., the transverse diameter of the heart is larger than half the width of the thorax. Its frontal surface area is relatively large.

In contrast to this is the heart silhouette of diagram *b* of the same figure, which represents the other extreme. Here the diaphragm is low with its dome approxi-

* *Mr*, the median right diameter, is the distance from the midline to the farthermost point of the right heart contour. *Ml*, the median left diameter, is the distance from the midline to the farthermost point of the left heart contour. *T*, the transverse diameter of the heart, represents the sum of *Mr* and *Ml* and therefore the maximal distance between the right and left heart borders. *L*, the longitudinal diameter of the heart, is the distance from the junction of the vascular and cardiac right arches to the outermost and lowest point of the cardiac apex. The angle of inclination is the angle formed by *L* and *Ml*. The cardiothoracic ratio represents the ratio of the transverse diameter of the heart to the inner diameter of the chest. The frontal surface area is the cardiac area on the posteroanterior roentgenogram after arbitrary completion of the upper and lower heart borders.

mately at the level of the posterior portion of the eleventh rib. The heart appears long and narrow and can be compared to a "standing egg." Its waist is not well marked, vascular and cardiac portions of the silhouette fuse into each other more gradually. The transverse diameter is smaller, *Ml* is less than twice the length of *Mr*, the longitudinal diameter *L* is more vertical, i.e., the angle of inclination is larger than 45 degrees, the cardiothoracic ratio is below 50 per cent, the frontal surface area is relatively small.

The two diagrams *a* and *b* represent, of course, extremes in cardiac types resulting from maximal deviations in the position of the diaphragm. Intermediate types are readily visualized. Diagram *c* of the same figure depicts such a heart whose diameters, relation of *Ml* to *Mr*, angle of inclination and cardiothoracic ratio fall between the measurements for the other two types. The terms "transverse heart" for type *a*, "vertical heart" for type *b*, and "oblique heart" for the intermediate type *c* are frequently used.

For the purpose of this discussion on the varying surface relationship of the heart, it is not very relevant whether differences in cardiac dimensions in the frontal roentgenogram are the expression of differences in actual cardiac size; in other words, whether enlargement or decrease in size of cardiac diameters of the frontal silhouette necessarily prove corresponding changes in heart volume. The answer is negative. As far as changes in individual diameters are concerned, it is of course readily seen that diminution in the transverse diameter may be compensated by lengthening of the longitudinal diameter. But even if planimetric determination of the frontal surface area demonstrates increase or decrease of the frontal silhouette, this does not necessarily indicate change in cardiac volume, since diminution of the frontal area may be balanced by a corresponding increase in cardiac depth, or vice versa. Thus to name one example, inspiratory reduction of the transverse diameter may be associated with increase or decrease in size of the longitudinal diameter. In the latter case diminution of frontal surface area is demonstrable. Yet this is no definite proof of reduction in cardiac volume for reasons just mentioned. Actually it has been demonstrated by volumetric determinations that inspiratory decrease in frontal surface area is consistent with increase, decrease or no change in cardiac volume.

Respiration. We have seen that the heart follows the inspiratory descent and expiratory rise of the diaphragm. In addition, the heart undergoes an inspiratory forward rotation of its apex around the longitudinal axis of the organ and a reverse movement in expiration. The movements vary with the intensity and type of breathing. While changes in cardiac configuration are not very marked in quiet breathing, large respiratory excursions of the diaphragm lead to distinct changes in the frontal silhouette of the heart. Thus deep inspiration results in a more vertical heart figure, while maximal expiration brings about a transverse configuration (Fig. 4*a*).

Body Posture. When the body changes from the vertical to the horizontal position, the heart ascends with the diaphragm and rotates around its own longitudinal axis so that the apex moves toward the left and posteriorly, assuming on the whole a more transverse shape (Fig. 4*b*, solid lines—supine position, dotted lines—vertical position). In the sitting position the heart frequently adopts an intermediate position, as shown in the same figure (Fig. 4*b*, dashes). These changes in cardiac position should be kept in mind in physical examination of the heart, where cardiac configuration may be studied in the standing, sitting, or recumbent position, depending on the wellbeing of the patient and the preference of the examiner.

Other Factors Affecting the Position of the Diaphragm. Respiration and changes in body posture are not the only physiological variants that affect the position of the diaphragm and consequently the configuration of the heart. Others are the state of

filling of the viscera, large deposits of fat in the abdomen, pregnancy, sex, age, and thoracic build. In general, it can be said that all factors that raise the level of the diaphragm, let the heart approximate the transverse type *a* of Figure 3, while all factors that lower the diaphragm, tend to produce a cardiac configuration similar to type *b*. The extent of diaphragmatic rise or descent determines also the degree of resemblance to the illustrated examples. Thus a normally oblique heart may assume transverse shape with maximal elevation of the diaphragm due to overfilling of the intestines (Fig. 5*a*). Or a heart which during the later months of pregnancy adopts a transverse configuration, will revert to its original oblique type during the puerperium (Fig. 5*b*).

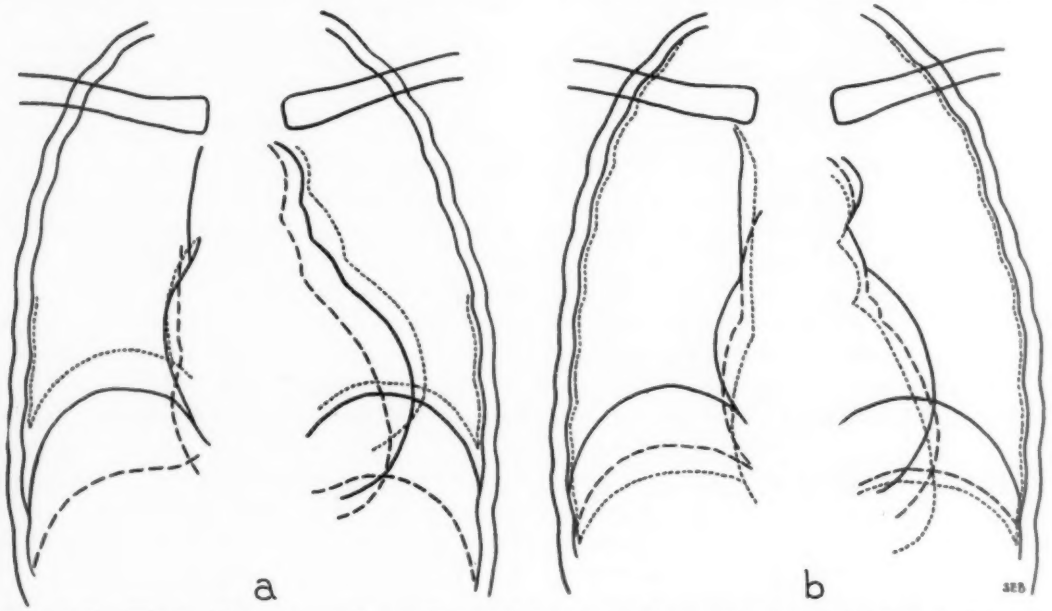


Fig. 4. (After Dietlen.[10]) *a*, changes in cardiac configuration during respiration. Solid lines indicate quiet breathing, dashes outline the heart and diaphragm in deep inspiration, dotted lines in expiration. *b*, changes in cardiac configuration with alterations in body posture. Solid lines indicate supine position, dashes outline heart and diaphragm in the sitting position, dotted lines in standing position.

The examples just mentioned have been chosen to illustrate the important concept of changing heart configuration as a result of variations in the position of the diaphragm. Usually the variations are not as marked as the extremes of Figure 3. In general, it can be said that low diaphragmatic position is accompanied by a more or less vertical heart with a smaller transverse diameter, a larger angle of inclination (larger than 45 degrees) and a cardiothoracic ratio of less than 50 per cent, while a high diaphragm is usually associated with a transverse heart of larger transverse diameter with a smaller angle of inclination and a cardiothoracic ratio greater than 50 per cent.

B. Constitutional Type

We have seen so far that the heart may change its configuration depending on changes in the position of the diaphragm. But there exist also variations from individual to individual which are the expression of differences in constitutional build. If we inspect a series of roentgenograms of normal subjects taken in the same respiratory phase and in the same position of the object, e.g., during quiet respiration and in the upright position, we encounter all three cardiac types described above, although not with equal frequency. The most common type, particularly in well proportioned

adult males, is the oblique heart, but the transverse and vertical hearts also occur frequently. A correlation can often be established between body habitus, configuration of the thorax, and the type of heart. Thus the tall, slender individual with the long, narrow thorax is most likely to have a vertical heart, while the heavy-set, stocky individual with a short and wide chest in all probability has a transverse cardiac silhouette. Intermediate types most frequently display an oblique heart. While this parallelism can be attributed partly to variations in diaphragmatic position—the diaphragm is commonly lower in the narrow chest and higher in the broader thorax—it also has its cause in variations in the shape of the chest as seen in cross sections. Apparently the heart adapts itself to the dimensions of the thoracic cavity so that deep-chested individuals have a larger depth diameter of the heart and flat-chested subjects a correspondingly flatter heart. But exceptions to this rule also occur. The use of the cardiothoracic ratio is based on the relationship between transverse diameter of the heart and width of the chest.

C. Age and Sex

The heart of the newborn and the young infant is globular in shape. Subdivision of its contours into clearly outlined arches is not present, its waist is obliterated due to protrusion of the pulmonary arch, and the aortic knob is frequently absent (Fig. 6*a*). The heart is of the transverse type with a small angle of inclination. Its transverse diameter is rather large and the cardiothoracic ratio is higher than 50 per cent. The silhouette as a whole is short, its vascular component wide. The described configuration is explained by: (1) the high position of the diaphragm, (2) the superimposition of the thymus, (3) differences in angulation of the longitudinal axis of the heart as compared with the heart of the adult (Zdansky[35]).

The high position of the diaphragm in the infant is normal and is exaggerated by large gas filling of the stomach and the intestine.

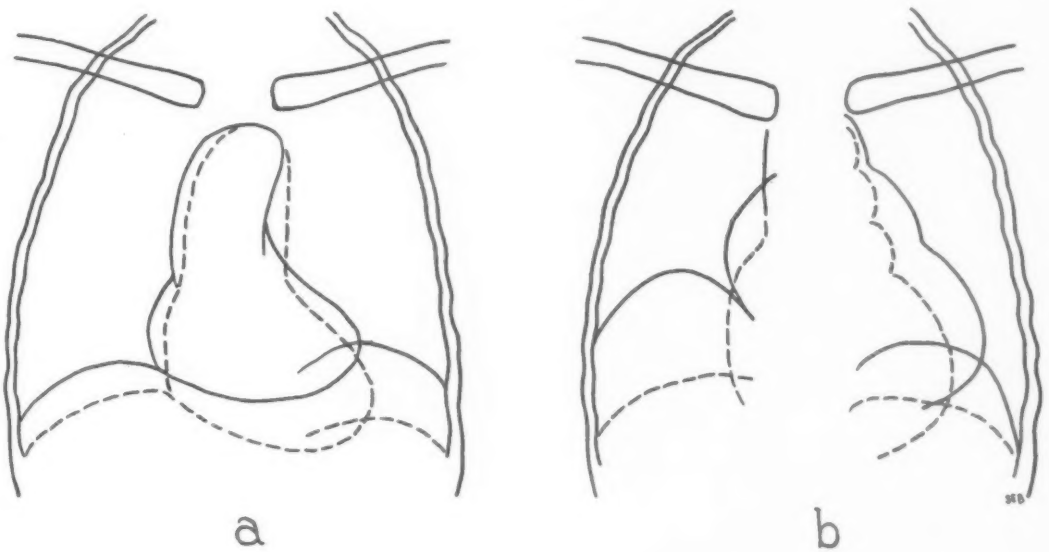


Fig. 5. Changes in the position of the diaphragm and in cardiac configuration: *a*, with variations in the filling of the intestines. Solid lines represent the position of heart and diaphragm before, and dotted lines after evacuation of distended intestines (after Kudisch[19]). *b*, during and after pregnancy. Solid lines indicate position of heart and diaphragm during ninth month of pregnancy, dotted lines depict position nine days postpartum (after Dietlen[10]).

The relatively large size of the liver is also a contributing factor. The shadow of the thymus fuses with the cardiac silhouette and usually cannot be separated from the latter. Differences in thymic size and shape also explain the marked variations of the mediastinal shadow in early infancy. The longitudinal axis of the infant's heart approximates the horizontal in the frontal plane—the angle of inclination is usually not larger than 20 degrees—as well as in the sagittal plane, as demonstrated in profile view, so that the large thoracic vessels, instead of running vertically upward, take an almost horizontal course with posterior inclination. This leads to considerable foreshortening and widening of the cardiovascular silhouette in the standard roentgenogram. Abnormal broadening of the vascular component of the shadow is often due to crying of the infant during exposure resulting in overfilling of the superior vena cava. Related to total body weight the heart of the newborn is larger than at any other age.

As age increases, the diaphragm descends and the thorax flattens anteroposteriorly. Thus the heart loses its pronounced transverse configuration and assumes more the shape of the adult heart. Correspondingly the cardiothoracic ratio decreases and the angle of inclination increases. All investigators of the child's heart note the great variability of all cardiac dimensions. During periods of particularly accelerated body growth heart size may temporarily lag behind other body measurements.

It would be expected that the descent of the diaphragm in advanced age should be accompanied by a lengthening of the heart shadow and change to a more vertical configuration, but contrary to expectations we find the heart in old age usually represented by the transverse type. This can be partly explained by rotation of the heart to adapt itself to elongation of the aorta (Fig. 6*b*). But actual increase in cardiac size in old age is also a factor.

The female heart approximates in general more the described infantile type. The waist of the heart may be obliterated. The silhouette frequently is of the transverse type with small angle of inclination and relatively large transverse diameter, particularly its *Ml* component. The causes for these peculiarities lie in the high position of

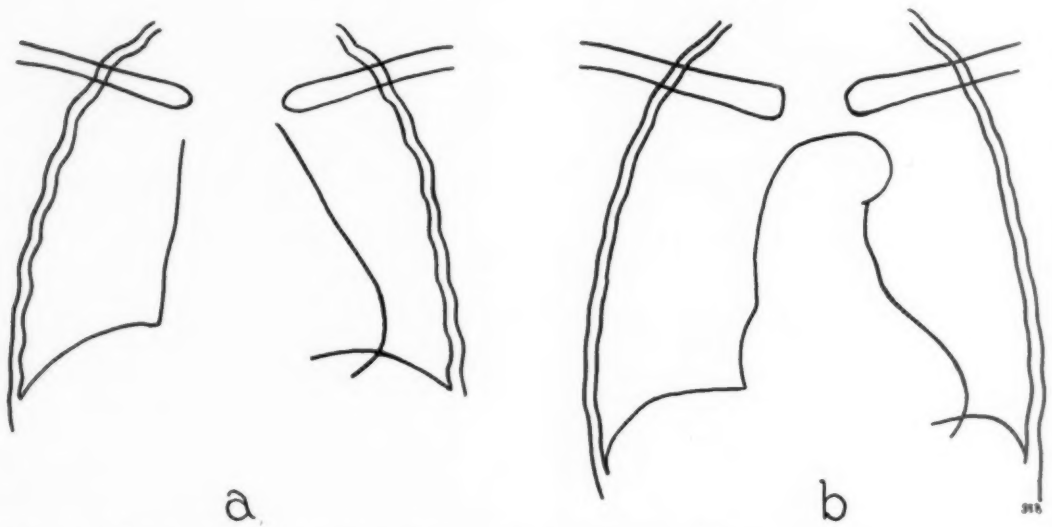


Fig. 6. *a*, infant's heart. No subdivision of its contours, obliteration of the cardiac waist, absence of aortic knob, large transverse diameter with cardiothoracic ratio greater than 50 per cent. *b*, senile heart. Heart of transverse type with protruding and elongated aorta.

the diaphragm and the shape of the female thorax which is short and deep.

D. Weight and Height

There is a direct correlation between heart size and body weight; indeed, heart size parallels body weight more closely than it does any other single factor. Further investigation reveals that more than any other body tissue the amount of skeletal musculature is the factor which is most closely related to the size of the heart. Thus, of two individuals of the same body weight, the one with the better developed skeletal musculature will usually have the larger heart. It also explains why obese persons commonly fall in their heart dimensions below the figures expected by their weight.

Heart size can also be correlated to body height. Tables show that cardiac dimensions rise with increasing height, but this holds true only for the harmoniously built individual. Where length development is not in proportion to body width, no correlation between heart size and body height exists. Thus the tall slender subject reveals cardiac measurements smaller than are expected from his height. In general, height does not parallel cardiac size as closely as weight.

E. Cardiac Phase and Pulse Rate

It is readily understood, yet often neglected in appraising cardiac size, that the heart is subjected to variations in size depending on the phase of the cardiac cycle, diastole leading to widening, systole to contraction of the silhouette. Orthodiagraphy, in order to exclude this source of dimensional variations, customarily outlines all cardiovascular contours in the diastolic position, i.e., at their maximal distance from the midline. Thus a silhouette is reproduced which actually never exists at any moment of the cardiac cycle.

Pulse rate is likewise of influence on heart size. Tachycardia, which causes shortening of the diastole and therefore a decrease in the stroke volume, produces a diminution of cardiac size, and bradycardia for opposite reasons, an increase in cardiac dimensions. But minor alterations in heart rate do not noticeably affect the size of the silhouette.

SURFACE PROJECTION OF THE HEART

The preceding discussion on the variability of cardiac configuration in the normal furnishes convincing proof that the standard figure on the surface projection of the heart, as given in anatomical texts, is of questionable value. It has been demonstrated that cardiac surface relationship is not a fixed and static entity, but is dependent on a series of variable factors, which have to be defined in the individual case. If for didactic reasons a single schematic representation is desired, it certainly should not depict the conditions in the cadaver, but in the living. Such a schematic figure can be obtained with sufficient accuracy only by means of roentgenograms. Variable factors within the same individual have to be reduced to their minimum by standardizing roentgenographic procedure, with particular attention to respiratory, postural, and pulsatory changes in the size, shape, and position of the heart. Recognized statistical methods should be employed to insure correct evaluation of variations between different individuals.

In view of the difficulties previously discussed, sufficient roentgenographic studies on the topography of the heart are not available to present this subject in final form. But roentgenographic data recently collected by Mainland and Gordon[25] give a chance to compare the facts at hand with those in the anatomical literature. From this evidence the assumption seems justified that the standard diagram of the projection of the heart on the anterior thoracic wall is incorrect in the living subject in the erect position. If the roentgenogram of the upright subject is taken in the neutral respiratory phase midway between inspiration and expiration, the following is the average position of the heart in the young male adult (Mainland and Gordon[25]):

Corner of Heart	Costal Level*	Distance from Midline
Upper left	Lower part of third rib	3 cm.
Upper right	Upper part of fourth rib	nearly 3 cm.
Lower right	Fifth intercostal space	4 cm.
Lower left	Lower part of sixth rib	7 cm.

Particularly important is the location of the lower cardiac border. It crosses the midsternal line 5.5 cm. below the xiphisternal joint.

The position of the heart as given in anatomical texts (Morris, 1933) is the following:

Corner of Heart	Costal Level	Distance from Midline
Upper left	1 cm. below second chondrosternal articulation	3 cm.
Upper right	1 cm. above third chondrosternal articulation	3 cm.
Lower right	Sixth costal cartilage	2 cm.
Lower left	Fifth intercostal space	7.5–8 cm.

* The designation "costal level" refers to the part of the rib or intercostal space overlying the cardiac shadow at the corner under investigation. Where, as in the case of the cartilaginous portion of a rib or intercartilaginous part of an intercostal space, the relationship cannot be read off directly from the roentgenogram due to the invisibility of the costal cartilage, the costal level was identified by wire markers (personal communication from Dr. Mainland).

The lower border passes from the apex through the xiphisternal joint.

The discrepancies of these two surface projections become most evident on diagrams drawn from the specifications of these tables (Fig. 7). A comparison reveals that the heart of the erect living subject lies considerably more caudad than the cadaver heart. Particularly striking is the contrast in the location of the lower border. This is determined by Mainland and Gordon from lateral roentgenograms and related to wire markers at the xiphisternal joint. After careful consideration the two authors find their result free from any bias.* They likewise call attention to the fact that the described location places the sternocostal surface of the heart in the erect subject almost as far below the xiphisternal joint as above it; in other words, a plane laid through the joint would nearly bisect the anterior surface of the heart. The main difficulty in visualizing the low extent of the inferior cardiac border lies in the fact that, according to general concept, the dia-

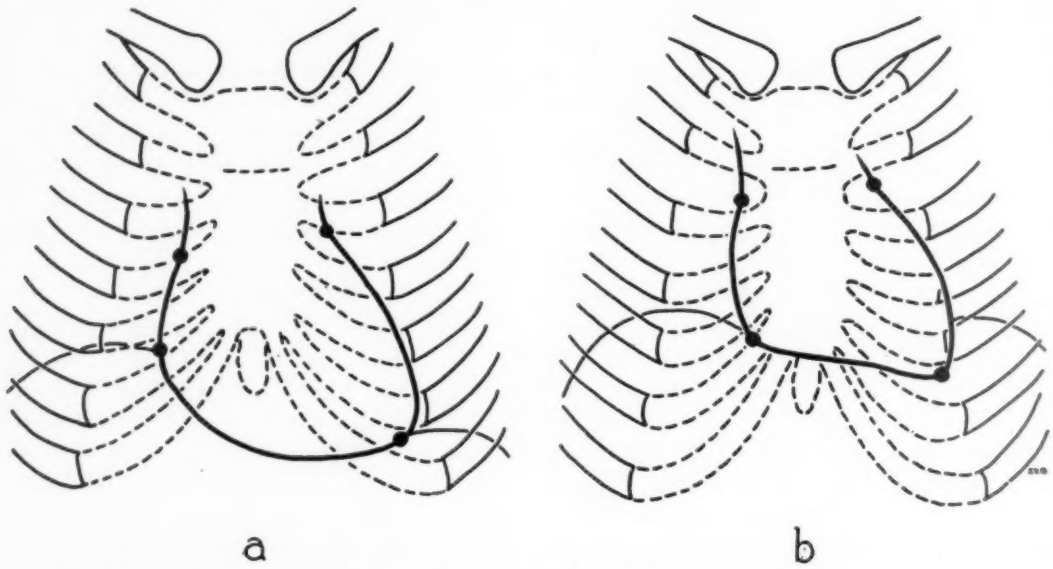


Fig. 7. Surface projection of the heart: *a*, in the upright living subject (drawing after data from Mainland and Gordon[25]). *b*, after Morris.[28]

* In a recent publication (D. Mainland: Anatomy as a Basis for Medical and Dental Practice, Paul B. Hoeber, 1945) the author concedes that the lower border of the heart in the midline should possibly be a centimeter higher, which would place it 4.5 cm. below the xiphisternal joint.

phragm passes from its insertion on the xiphoid process backward and upward. This would of course preclude the heart from reaching a level more caudad than the xiphoid process, at least in the midline. Since the roentgenograms definitely reveal the inferior border of the cardiac silhouette below this landmark, the diaphragm must pass from the xiphoid process not backward and upward, but first backward and downward allowing for the caudal expansion of the heart which produces a distinct impression on the liver. This is also the explanation which Mainland and Gordon offer for this surprising result.

The discrepancy in the location of the lower right corner of the heart seems to be more one of definition than of actual topography. Anatomical texts apparently place it at the termination of the inferior vena cava, while Mainland and Gordon locate it somewhat more laterally at the point of the cardiac silhouette where diaphragm and right border of the heart meet. The former definition seems more acceptable.

In view of the discrepancies between the topography of the heart in the upright, living individual and in the cadaver the question is indicated: How does the position of the heart in the recumbent living subject compare to its location in the cadaver? In the horizontal position the diaphragm is considerably higher, and the heart therefore should approximate the cadaveric location. Again reference is made to investigations by Mainland and Gordon who give the following surface projection of the heart in this state:

Corner of Heart	Costal Level	Distance from Midline
Upper left	Upper part of third rib	nearly 4 cm.
Upper right	Lower part of third rib	3 cm.
Lower right	Fifth rib	4 cm.
Lower left	Lower part of fifth intercostal space	7.5 cm.

The lower border crosses the midline 3.5 cm. below the xiphisternal joint.

Leaving aside the differences in the location of the right lower corner which have been explained, we see that the surface projection of the living heart in recumbent subjects approximates the cadaveric position much closer than in the upright individual, although it still is not situated as far craniad as textbooks describe it.

Summarizing these observations on the location of the heart in the living, we notice that there are considerable differences between the conventional descriptions and the roentgen findings in the upright, living subject. Here the heart lies much lower than usually assumed. Particularly surprising is the location of the inferior cardiac border, which is given as crossing the midline on the average 5.5 cm.* below the xiphisternal joint. The heart of the recumbent living subject approximates the cadaveric position, but still does not lie as far craniad. The results of these interesting studies require confirmation on a series of individuals which is more representative of a cross section of the whole population than the authors' young male student material, but it is anticipated that a revision of our concept of cardiac topography is necessary.

Although the position of the heart valves cannot be determined directly on the roentgenogram of the living, it can be deduced from the foregoing description that the standard anatomical diagram of the surface projection of the cardiac valves is not correct for the upright individual. Further investigations, particularly with the help of contrast filling of the heart chambers, are needed to put our concept of the location of these valves in the living on a more exact basis.

TOPOGRAPHIC ANATOMY OF LUNGS AND PLEURA

The lungs and pleura are not as favorable an object for roentgenographic study of their topography in the living as the heart. Large portions of the lungs are invisible on the standard roentgenogram, since they are concealed by the homogeneous abdominal and mediastinal densities. As to the normal

* 4.5 cm. according to a recent correction by Mainland (see preceding footnote).

pleura, the contention is frequently made that it is entirely outside the realm of roentgenographic demonstrability. On closer scrutiny, conditions are not as unfavorable. The normal pleura can be visualized under propitious circumstances, i.e., if the rays strike the pleural surface tangentially to a sufficient extent and if there is adequate contrast between the pleural membrane and adjacent regions. This is exemplified by the visibility of the normal visceral pleura in pneumothorax where it is bounded by air-containing spaces on both sides. It is further illustrated by demonstration of the normal interlobar septum and of the interlobar fissure in accessory lobes. While it is true that considerable portions of the lungs are obscured by adjacent abdominal organs and the mediastinal shadow, proper technique and favorable conditions in the subject not infrequently reveal the posterior mediastinal and posterior inferior extent of lungs and pleura. It seems a worthwhile undertaking to compare these boundaries with those found in the cadaver.*

A. Posterior Mediastinal Boundaries of Lungs and Pleura

According to conventional anatomical teaching the posterior costal pleura is continuous with the mediastinal pleura along a vertical line on the anterolateral aspect of the vertebral bodies. This line of pleural reflection extends from the first to the twelfth thoracic vertebra, where it becomes continuous with the diaphragmatic reflection. The extent of the lungs in the posterior mediastinal region is supposed to coincide with the line of pleural reflection. The posteromedial margins of lungs and pleura define also the configuration of the posterior portion of the mediastinum. This is consequently regarded as a rather wide space in which the esophagus is in close contact with the anterior surface of the spinal column.

What are the roentgen findings relating to these boundaries of lung and pleura? A number of detailed roentgenographic studies on this subject are available (Pratje,[32] Danelius,[8,9] Bársony and Wald,[4] Stéphani and Kirsch,[34] Maier,[24] Lachman[21]), but they have so far not been included in our teaching of this important chapter of topographic anatomy. The demonstration of these boundaries on the routine chest roentgenogram is rare; only on films taken with high roentgenographic penetration and preferably with a Potter-Bucky diaphragm is it at all possible to identify the upper medial lung portions as a more translucent area superimposed on the shadow of the spinal column. The medial contour of this translucency describes a medially convex arc which arises in the apical field and continues downward in or close to the midline (Fig. 8). At the level of the fourth or fifth thoracic vertebra the lung margins of the two sides approximate each other leaving but a small interval between them. In addition to the pulmonary translucency the corresponding pleural reflections of the two sides may appear as thin lines visible within the tracheal translucency (Fig. 8).

In stereoroentgenographic studies in the living with barium filling of the esophagus, Pratje[32] demonstrated that the distance between esophagus and spinal column at the level of the fourth and fifth thoracic vertebra amounts to 2–4 cm. This space is occupied by pleural recesses into which medial portions of the lungs extend. In roentgenographic investigations on the cadaver and in the living, Danelius[8] confirmed the presence of a retro-esophageal space which is occupied by lungs and pleura. This space deepens during inspiration and in the upright position, while it becomes more shallow during expiration and in the supine posture. The space is larger where the thoracic curvature is pronounced or where there is a distinct thoracic kyphosis, and it may be absent if this curve

* Other pulmonary and pleural boundaries, e.g., the anterior mediastinal or anterior inferior, are excluded from this discussion, since they can be visualized on the roentgenogram only in rare instances.

is ill defined. Presence of lung and pleura in this retro-esophageal location is more common on the right side, and the right mediastinal pleura frequently encroaches on the territory of the left pleura by crossing over the midline.

In the light of these roentgenographic investigations, we must revise our concept of the upper mediastinal boundaries of lung and pleura. Very instructive is a comparison of cross sections illustrating the two concepts. In Figure 9*a*, the lungs and pleural cavities according to conventional anatomical description are separated posteriorly by a wide mediastinal space in which the esophagus is found directly in front of the spinal column. In contrast to this, the corrected diagram *b* depicts the esophagus overlapped posteriorly by retro-esophageal portions of lung and pleura.

In a recent anatomical study (Lachman[21]) attention has been called to the interesting fact that, while older continental

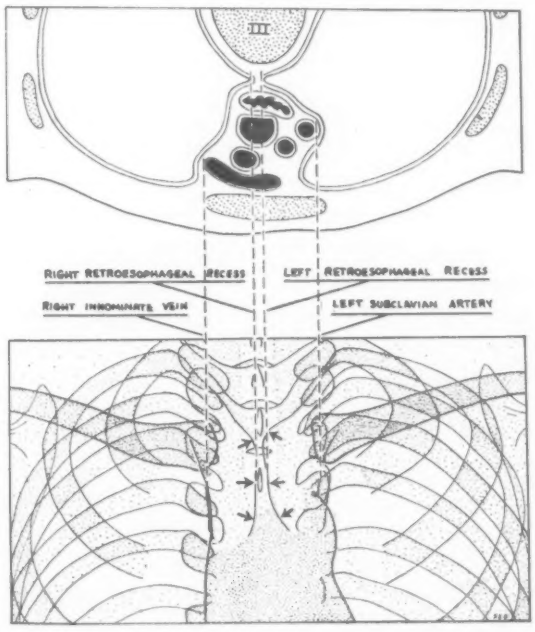
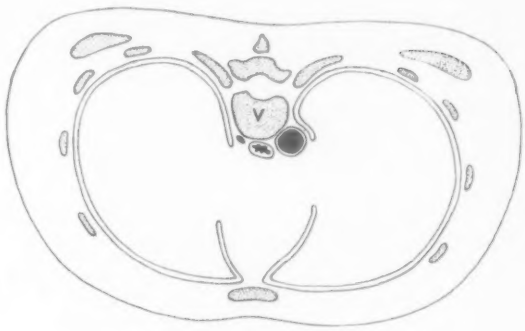
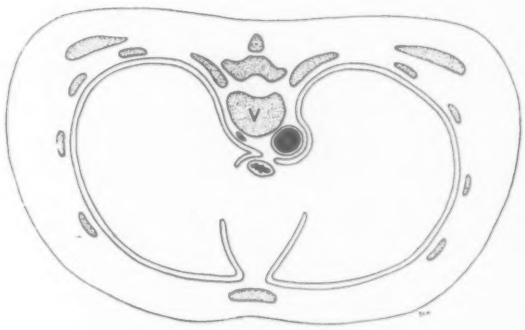


Fig. 8. *Upper:* Cross section through mediastinum at level of third thoracic vertebra. *Lower:* Diagram after roentgenogram depicting the lungs in the retro-esophageal pleural recesses superimposed on trachea and spinal column. Dotted lines indicate the anatomical substrate of pleural lines and of vascular contours in cross section.



a



b

Fig. 9. Cross section through the posterior mediastinum at level of fifth thoracic vertebra. *a*, diagram according to conventional anatomical teaching. *b*, diagram incorporating roentgen findings in the upright living subject. Observe retro-esophageal pleural recess containing lung on right side in *b*.

anatomists were familiar with this retro-esophageal recess, almost all our current English texts disregard it. Few data are available dealing with the frequency of the prevertebral cul-de-sac. Heiss,[15] who undertook careful anatomical investigations on the posterior pleural boundaries of the mediastinum by means of injection of solidifying material and following dissection, found the recess in 70 per cent of his cases. He further states that the rest of his cadavers showed irregular posterior pleural boundaries which almost never confirmed the conventional textbook descriptions. Stéphani and Kirsch[34] observed roentgenographic expansion of the right lung into the mediastinal region beyond the midline in

30 per cent of their cases. The recess is most often visualized in children and in subjects with marked dorsal curvature. The upright position and deep inspiration are required

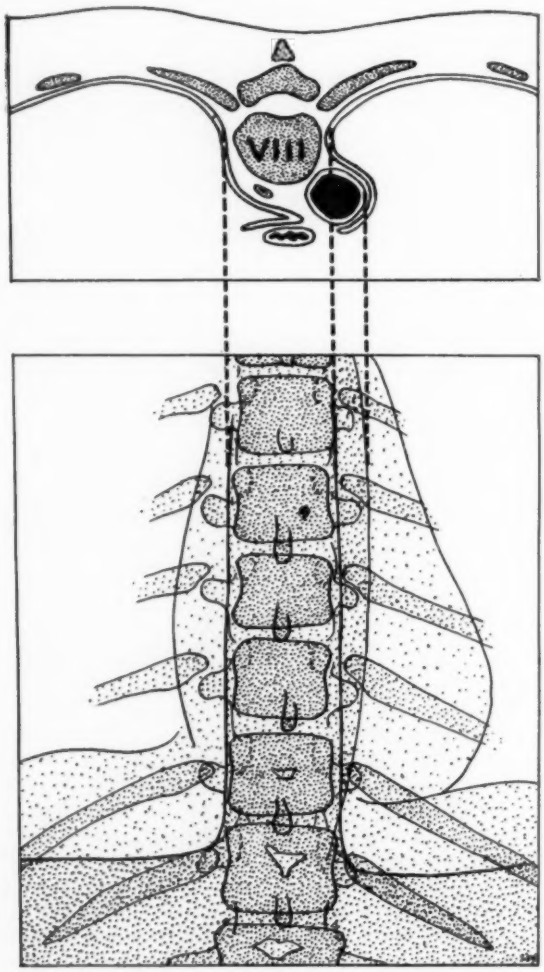


Fig. 10. *Upper:* Cross section through posterior mediastinum at level of eighth thoracic vertebra. *Lower:* Diagram after roentgenogram depicting posterior portions of visceral and/or parietal pleura as lines accompanying the vertebral column. Dotted lines indicate the anatomical substrate of pleural lines and of aortic shadow in cross section. (From Lachman.)[21] (Reproduced by permission from *Anat. Rec.*, 1942, *83*, 521–542.)

to demonstrate the maximum medial extent of the lungs. In the supine position and in expiration the lungs apparently recede from the pleural cul-de-sac. Insufficient data are available to demonstrate the possible variability of pleuropulmonary topography with age and constitutional factors.

Although older anatomists have called attention to the presence of a pronounced pleural recess in the lower posterior mediastinum, it has not been possible to demonstrate it roentgenographically below the fifth thoracic vertebra; indeed a paravertebral roentgenographic line has been described to the left, and more rarely to the right of the spinal column which is attributable to tangential projection of the paraspinal margins of the mediastinal pleura (Lachman,[21] Garland,[12] Brailsford[6]). The presence of these pleural lines to the sides of the spinal column seemingly precludes the possibility of pleural cul-de-sacs extending to or over the midline. Yet this is not necessarily the case, since the appearance of pleural lines farther laterally corresponding to the most posterior portions of the pleura does not rule out the presence of pleural recesses more anteriorly behind the esophagus, and therefore does not disprove the correctness of older anatomical observations (Fig. 10) (Lachman).

B. Posterior Inferior Boundaries of Lungs and Pleura

The posterior inferior margins of the pleura are customarily described as horizontally or medially ascending lines which meet the spinal column at the level of the twelfth costovertebral articulation. Some texts locate the inferior extent of the pleura half a vertebra lower. The lower posterior boundaries of the lungs are given as one to two intercostal spaces higher than the pleural margins. This information is based on studies of fresh or preserved cadavers. In the former case, the diaphragm has reached its highest possible position and the lungs are in a state of total collapse, thus producing an entirely unnatural position of the pulmonary margins. In the preserved cadaver the location of the lower lung boundaries is said to correspond approximately to the neutral respiratory phase, i.e., a state of quiet breathing. In inspiration the lungs are supposed to extend to the

level of the spinous process of the eleventh thoracic vertebra, a finding which is based on percussion. This method, while entirely capable of demonstrating roughly the respiratory excursions of the lung margins, is hardly exact enough to determine the lowest inspiratory extent of the tapering lung margins. Consequently there is no agreement as to whether the lungs completely fill the costodiaphragmatic recesses in deepest inspiration.

In addition to the respiratory phase, the following factors influence the position of the inferior pleural and pulmonary boundaries: age, constitutional factors, and posture. During the life span of the individual the diaphragm, and with it the pleural sac and the lungs, is subject to a general descent. The quasi-normal emphysema of old age leads to an additional lowering of the inferior lung margins. Constitutional differences are likewise responsible for variations. The thoracic viscera are low in the slender, asthenic individual, while the diaphragm is high and the lungs are short in the hypersthenic type. With change in posture there also occurs a change in the position of diaphragm and thoracic viscera. The inferior pleural and pulmonary margins are lower in the standing than in the supine position. In the prone posture the diaphragm and the thoracic viscera are displaced upward by pressure from the abdominal viscera.

Sufficient roentgenographic information on the inferior pleural and pulmonary margins has been accumulated during the last ten years (Ottonello,[29] Bársony and Koppenstein,[3] Peltason and Neumann,[31] Korol,[17] Lachman[21]) to regard the boundaries given in the anatomical literature with reservation, as far as the living individual is concerned. As a matter of fact, these margins are more commonly seen on the roentgenogram than the previously discussed mediastinal boundaries. In our own material they were demonstrable in approximately 15 per cent as an incidental finding in the study of the abdominal viscera. Consequently they were usually visible with the subject in the prone position and with the roentgen rays traversing the body in dorsoventral direction. In this projection we often find a line running horizontally or with medial ascent or upward concavity from the lateral thoracic wall toward the spinal column at any level from the upper margin of the twelfth thoracic vertebra to the lower margin of the second lumbar vertebra (Fig. 11 and 12). Adjacent to the lateral contour of the spinal column the line takes an upward turn and can be traced in its vertical course for several vertebrae. In combination with the cupola of the diaphragm craniad to it the line circumscribes a translucent space of oval shape in which lung markings can be observed. The latter can be seen extending down close to the line under discussion, but never beyond it. On bronchograms the lowest extent of the bronchial filling also corresponds in form and position to the line (Korol[17]). The anatomical substrate of this line is the posterior costodiaphragmatic reflection of the pleura, while the medial and upward extent of the line represents the lowest portion of the posterior mediastinal pleura. The oval space just described corresponds to that part of the lower lobe of the lung which is located behind the dome of the diaphragm.

The prone position and the inspiratory phase are especially favorable for visualization of the line and space, since the posterior portions of the lungs are then maximally aerated and attain their greatest expansion into the costodiaphragmatic sinus, thus producing conditions of optimal contrast. Yet our own roentgenographic material which was taken in arrest of quiet breathing showed the pleural line and the adjacent pulmonary translucency in approximately 15 per cent of all abdominal cases.

The line under discussion is subject to wide variations in form and position. Figures 11 and 12 illustrate these variations in normal cases taken from our own material. Each of the lines in Figure 12 represents one or more cases in which the pleural

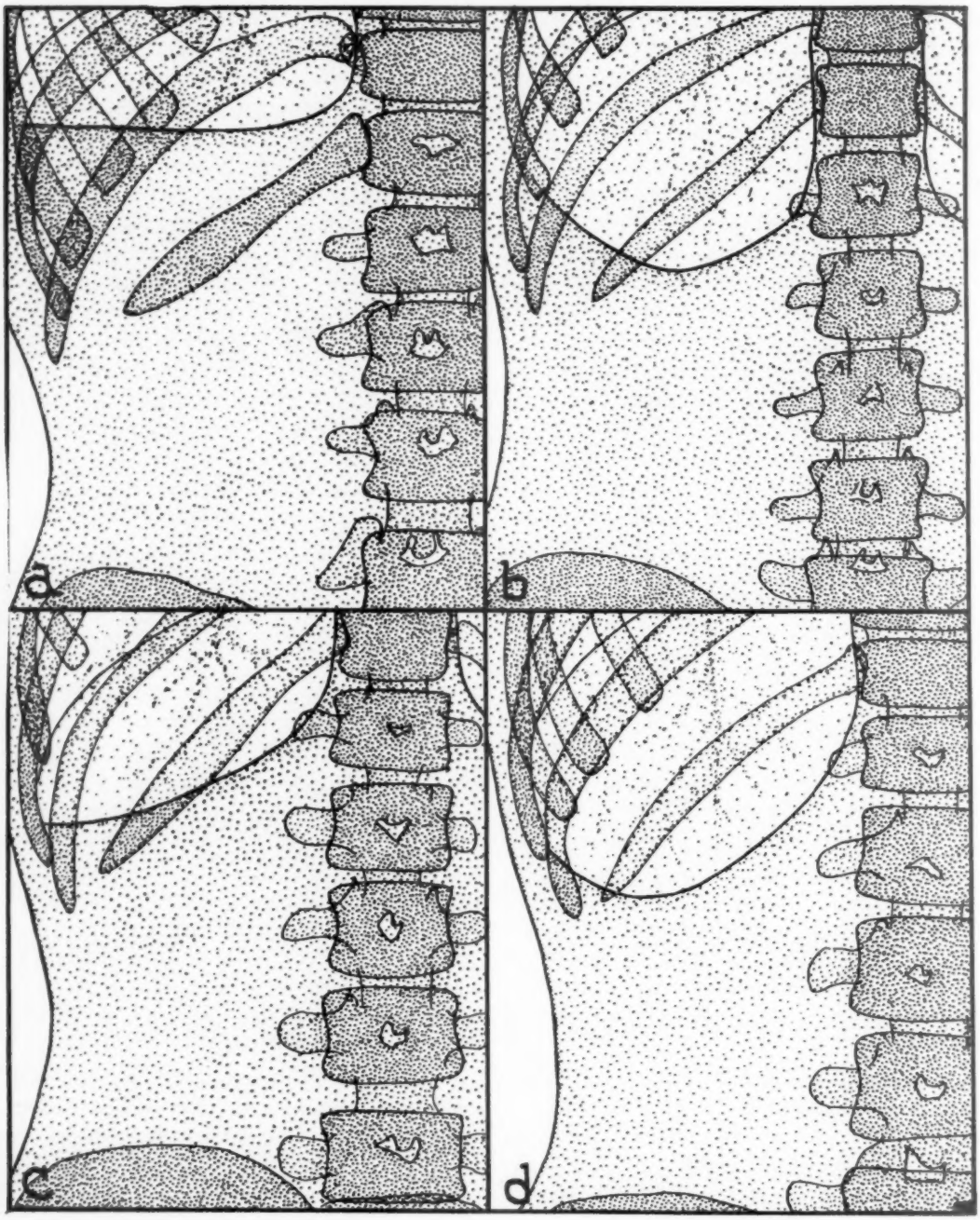


Fig. 11. Diagrams after roentgenograms of the right hypochondriac region. Observe the horizontal course of the pleural line in *a*, its medially ascending direction in *c*, and its upward concavity in *b* and *d*. The level of the line corresponds to the upper margin of the twelfth thoracic vertebra in *a*, and to the lower margin of the second lumbar vertebra in *d*. (From Lachman.[21]) (Reproduced by permission from *Anat. Rec.*, 1942, *83*, 521–542.)

line was clearly visible. Although the roentgenograms were all taken in the same respiratory phase and position, we notice a wide range in the location of the line. In only 6 out of 46 cases does the line correspond to the pleural margin given in

Cunningham (Fig. 12, left side), and in only 3 to the one given in Morris. Particularly interesting is the upward concavity of the line which is rather common in our material, but which has not been mentioned at all in anatomical descriptions. Roentgenographically the pleural line is more commonly found on the right side. If it is visible on both sides, then its course and location are usually identical on the two sides.

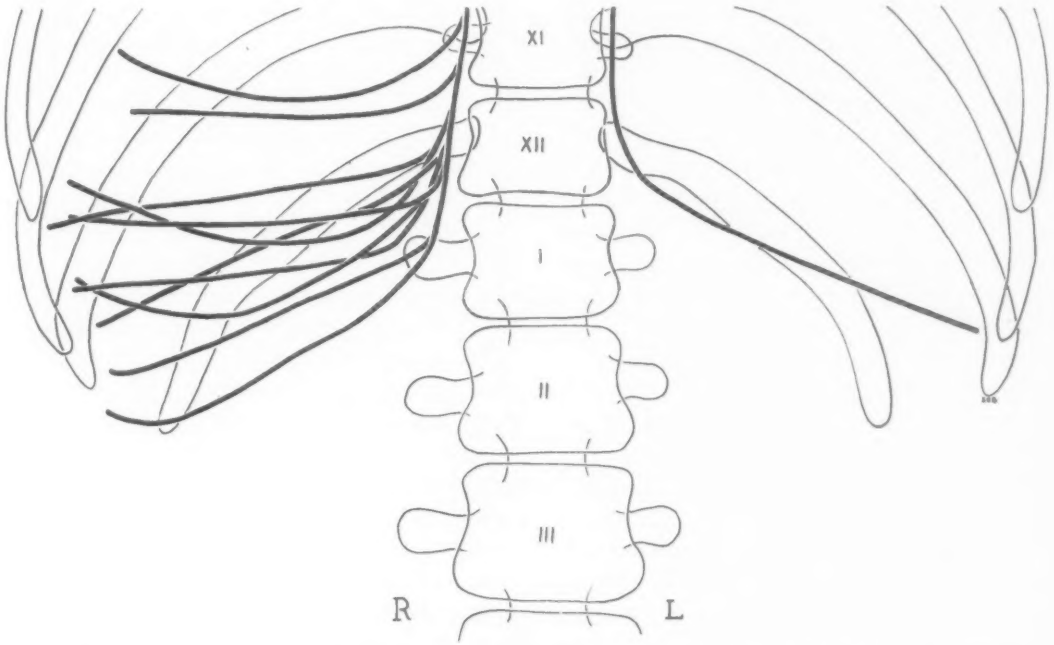


Fig. 12. Variations in the course of the pleural line according to roentgenograms in the prone position on the right; on the left the posterior inferior pleural reflection is drawn according to Cunningham.[7]

The position of the line varies with the constitutional type of the individual, assuming its greatest concavity and lowest level in the asthenic individual (Fig. 11*d*). In cases where we were able to demonstrate the line in the supine position, the location did not differ essentially from that observed in prone subjects.

In comparing these roentgenographic findings with the descriptions in the anatomical literature we notice that the posterior inferior margins of the lungs and pleura of the prone and supine living subject usually reach a lower level than is attributed to them by anatomists. The frequently demonstrated upward concavity of lower lung margins and pleura has not been mentioned. The great normal variability in the shape and position of this pleural reflection is likewise worth noting, also its lowest possible extent in the neutral respiratory phase down to the level of the second lumbar vertebra. It is probable that in deepest inspiration and in the anatomical, i.e., upright position the lowermost site of this pleural reflection may be still farther caudad. The presence of the pulmonary translucency and of lung markings in the previously described oval space proves that in the prone subject the lungs penetrate farther into the pleural sinus even in expiration than is generally assumed. For practical purposes, e.g., in operations on the prone patient, the possibility of the low extent of lung and pleura must be kept in mind to avoid inadvertent opening of the pleural cavity with resulting collapse of the lung and the unnecessary exposure of the pleura to infection.

CONCLUSIONS

The preceding examples chosen from different fields of thoracic anatomy have proved sufficiently that the topographic concepts of conventional anatomy do not cover adequately the wide range of the normal as revealed by roentgenographic exploration. These normal variations are the expression of alterations in the physiological state of the body or are due to differences in the constitutional make-up of individuals. The static and rigid surface anatomy of our present textbooks including those dealing with physical diagnosis should be replaced by a more flexible approach that takes account of this variability. The position of thoracic organs in the cadaver differs in many respects from that found in the living and cannot serve as a proper norm for clinical purposes. The study of the surface relationship of the thoracic viscera in the cadaver seems therefore of questionable value and should be replaced, wherever possible, by roentgenographic investigation in the living. Roentgenographic study of the topography of the thoracic organs, although still in its beginning and laboring under many handicaps, has already proved its value in the determination of the surface relationship of the trachea, the heart, and the posterior pleural and pulmonary boundaries.

The shape of the posterior mediastinum in the upright individual deviates apparently from the customary accounts of its anatomy. The contents of the subdivisions of the mediastinum in the erect subject do not coincide completely with those found in the supine cadaver. Thus the bifurcation of the trachea and the arch of the aorta may be located below the dividing line of the superior and inferior mediastinum instead of in the superior mediastinum where our textbooks place it.

The concept of the upright posture as "the anatomical position" is not consistent with the topographical descriptions of our texts and therefore should not be retained at the present time. It might be reintroduced after sufficient roentgenographic data on the shape and position of the viscera in the upright living individual have been collected. For the time being, the concept of the anatomical position might profitably be discarded and positional terms such as superior, inferior, anterior, and posterior could be replaced by designations such as cranial, caudal, ventral, and dorsal, that do not relate to any particular position of the body. If it seems impossible to abolish such time honored terms as superior vena cava and inferior lobe of the lung, attention should be called to the fact that these designations do not imply a vertical position of the body as far as conventional topographical descriptions are concerned.

SUMMARY

1. Since roentgen studies on the topographic anatomy of the abdominal viscera in the living have proved that their position is extremely variable and that the conventional fixed relationships of the organs pertain only to the cadaver, similar investigations on the thoracic viscera are indicated, but only few have been undertaken so far.

2. According to anatomical teaching the bifurcation of the trachea is placed at the level of the intervertebral disc between the fourth and fifth thoracic vertebra. But roentgenography reveals that in the upright adult subject it is usually considerably lower. The bifurcation is at its highest level during earliest infancy and then participates in the general descent of the viscera which takes place during the life span of the individual. Contrary to anatomical teaching the bifurcation of the trachea is not fixed, but undergoes a respiratory shift.

3. Many factors contribute to make the configuration of the heart extremely variable in the living; foremost among these is the position of the diaphragm which is influenced by respiration, body posture, the state of filling of the abdominal viscera, fat content of the abdomen, etc. Other factors responsible for variations are the constitutional type of the individual, the age

and sex, weight and height, and the cardiac phase and pulse rate.

4. In view of the variability of cardiac configuration the introduction of a single scheme as the standard surface projection of the heart appears of questionable value. But if for didactic purposes a single schematic representation is desired, it should not be based on conditions in the cadaver, but on roentgen studies in the living, with particular attention to respiratory, postural and pulsatory changes in cardiac configuration.

5. Mainland and Gordon[25] have collected sufficient data on the surface projection of the heart in the living to compare it with conventional textbook descriptions. This comparison reveals considerable differences. The heart in the erect living subject lies much lower than usually assumed. Particularly surprising is the location of the inferior cardiac border, which is given as crossing the midline 4.5 centimeters below the xiphisternal joint. The heart of the recumbent living subject approximates the cadaveric position, but still does not lie as far craniad as the latter.

6. Results of roentgenographic studies on posterior mediastinal and posterior inferior boundaries of lungs and pleura in the living are likewise not in complete agreement with conventional anatomical teaching. According to the latter the lungs and pleural cavities are separated posteriorly by a wide mediastinal space in which the esophagus is located directly in front of the spinal column. In contrast to this, roentgenograms occasionally depict the presence of a prevertebral space which is occupied by lung and pleura. The posterior inferior pleural reflection is characterized roentgenographically by a line running horizontally or with medial ascent or upward concavity from the lateral thoracic wall toward the spinal column at any level from the twelfth thoracic to the second lumbar vertebra. A translucency craniad to it is produced by inferior lung portions located behind the dome of the diaphragm. Anatomical presentations usually place the inferior pulmonary and pleural boundaries higher and disregard the commonly found upward concavity of the pleural reflection.

7. These examples from the field of mediastinal and pleuropulmonary anatomy prove sufficiently that the topographic concepts of conventional anatomy do not cover adequately the wide range of the normal as revealed by roentgenographic exploration. A more flexible approach is necessary that takes account of this variability. The position of the thoracic organs in the cadaver cannot serve as a proper norm for clinical purposes. As far as topographical anatomy is concerned, studies on cadavers should be replaced, wherever possible, by roentgenographic investigation in the living, which has already proved its value.

8. The concept of the upright posture as "the anatomical position" is not consistent with the topographical descriptions of our texts and can hardly be retained at the present time. It might be reintroduced after sufficient roentgenographic data on the surface relationship in the upright living subject have been collected. Positional terms presupposing a definite posture could be replaced by designations that do not relate to any particular position of the body.

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PORENCEPHALY*

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PORENCEPHALY is the occasional end point of many disease processes.

Since the term porencephaly was first used, it has been variously defined. Perhaps the most widely accepted definition is that of LeCount and Semerak[11] who describe "a defect communicating with the ventricles or separated from them by a thin layer of brain tissue, and covered on the outside by the arachnoid." Others[19] believe that, roentgenologically, any defect communicating with a ventricle and appearing in the tissues may be considered a porencephaly.

Porencephaly may be broadly classified as developmental or acquired in origin. The developmental defect may be the result of gene abnormalities or injury of the germ plasm before fertilization.[10] LeCount and Semerak[11] and Eisenstein and Taylor[5] believe congenital vascular defects may cause porencephaly. The acquired factors which may be etiologically significant are somewhat interrelated and may appear in intrauterine life,[2] at birth,[10] in post-natal,[21] and in later life.[18] They may be classified as traumatic, vascular, and inflammatory. Jaffé[9] believes that trauma is the most important causative agent. He stresses the importance of the secondary circulatory disturbances in the large veins due to backing up of blood in the venous sinuses. Vascular accidents such as hemorrhage, embolism and thrombosis may lead to porencephaly. This has been observed experimentally[6] as well as clinically.[13,15] Globus[8] believes that endarteritis and thrombosis are the predominant causative factors in porencephaly resulting from meningo-encephalitis. Penfield[16] has observed constriction of large pial arteries capable of arresting blood flow after convulsions in habitual epilepsy. He believes that focal atrophy and porencephaly may result from repeated episodes of localized vascular spasm. He further believes that convulsive episodes occurring in children with acute febrile illnesses may be caused by cerebral thrombosis secondary to severe dehydration. Localized atrophy and porencephaly may then result. Inflammatory lesions such as tuberculosis,[22] syphilis,[11] and encephalitis have been described as underlying causes of porencephaly. The very multiplicity of possibilities in many instances makes it difficult to establish the underlying cause. The etiology was not definitely determined in 17 of the 29 cases herein reported. Wilson,[21] distinguishing the true or developmental porencephaly from the acquired, says the acquired type is cystic rather than crateriform, does not always lead to ventricular fenestration, may contain yellowish albuminous fluid and is not lined by smooth gyral formation, but by a membranous wall adherent to the white matter of the centrum semiovale. Jaffé[9] believes that a porencephaly formed in the immature brain may be differentiated from that in the mature organ by the lack of mesenchymal proliferation in the wall of the cyst formed in immature tissue. Sixteen of our 29 cases were operated upon or autopsied and none of them fulfilled all of Wilson's criteria for the developmental type or "true" porencephaly. Five of the cases were apparently caused by intrauterine or birth injuries, 3 by trauma later in life, and 2 by encephalitis.

Porencephaly is a condition which must be considered in the differential diagnosis of mass or contracting lesions involving the brain. Occasionally it is confused with other cystic lesions clinically, roentgenologically and even microscopically. Since porencephaly is a benign condition, its recognition is important in determining prognosis and therapy. De Sanctis and his

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co-workers[4] believe "the necessity for clinical diagnosis cannot be overemphasized, for it leads to both confirmatory diagnostic procedures and treatment, the latter alleviating the condition entirely or in part."

Our series consists of 29 cases of porencephaly. All were studied by encephalography or ventriculography and 16 were subjected to craniectomy.

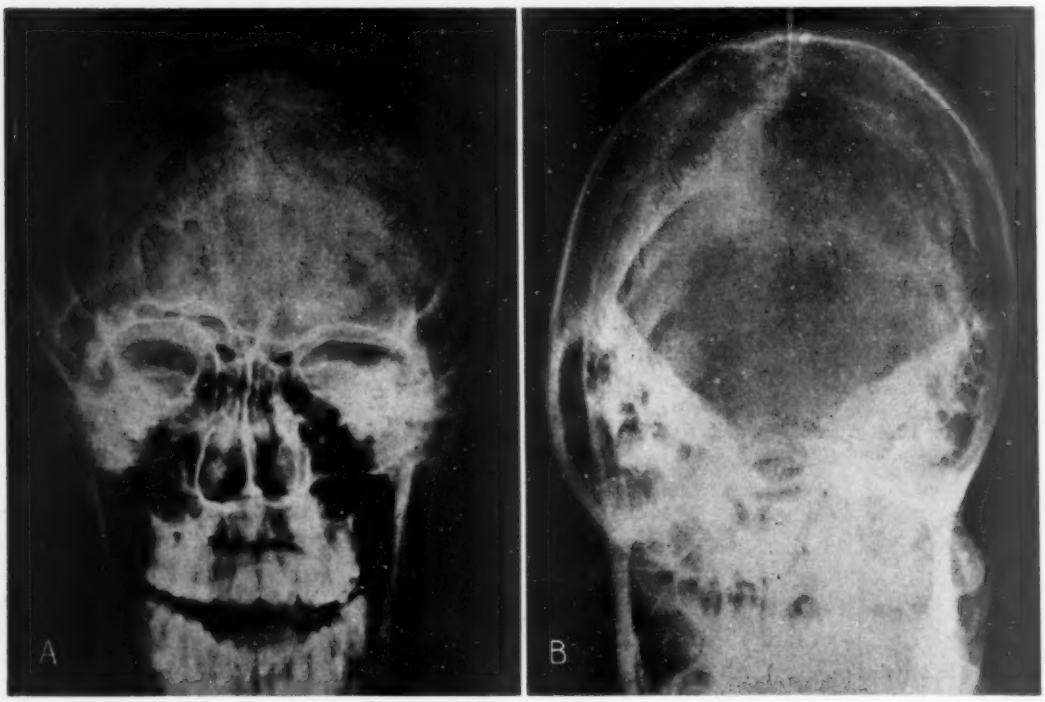


Fig. 1, *A* and *B*. Conventional roentgenograms of a male patient, aged thirty with an extensive porencephaly of the right hemisphere causing thinning of the inner table of the vault and disappearance of the diploic space on the right side. These changes were thought to result from an atrophy produced by transmitted pulsation through the fluid in the porencephaly from the ventricular system with which it communicated. The under development of the right side likewise resulted from the porencephaly.

The average age of the patients was sixteen, the oldest being thirty-four years and the youngest nine months. The duration of symptoms varied from three months to lifetime (thirty years). Most patients (26) sought medical attention because of epileptic attacks, which usually had been preceded for several years by other symptoms such as weakness of an extremity, strabismus, or mental retardation. Others complained of headache, poor memory, irritability, sluggishness, and excitability. In studying the psychiatric aspects of porencephaly, Bernstein[1] found poor social and sexual adjustment, sluggishness, feelings of inadequacy, deficient powers of generalization, and inability to concentrate in most of his patients. He believed the only possible difference from the usual epileptics would be the inability to concentrate and the deficient powers of generalization. The psychiatric picture did not differ greatly from some syphilitic, encephalitic and neoplastic patients.

Sixteen of the series had paresis or paralysis of one or two extremities and 2 of these had facial paralysis as well. Atrophy or hypodevelopment of one-half of the body or the involved extremity was present in those who had had paralysis since early childhood. Occasionally anesthesias were present. The importance of the

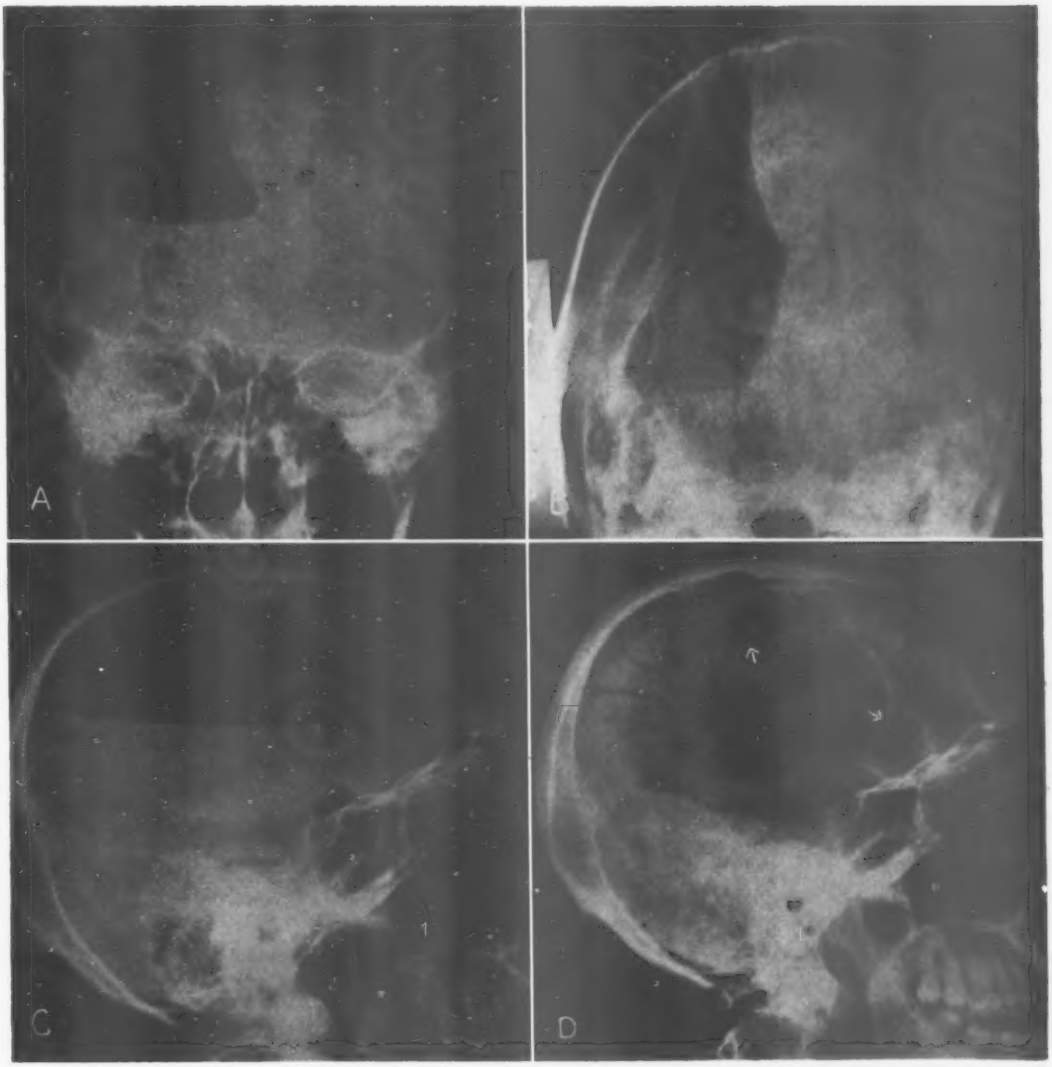
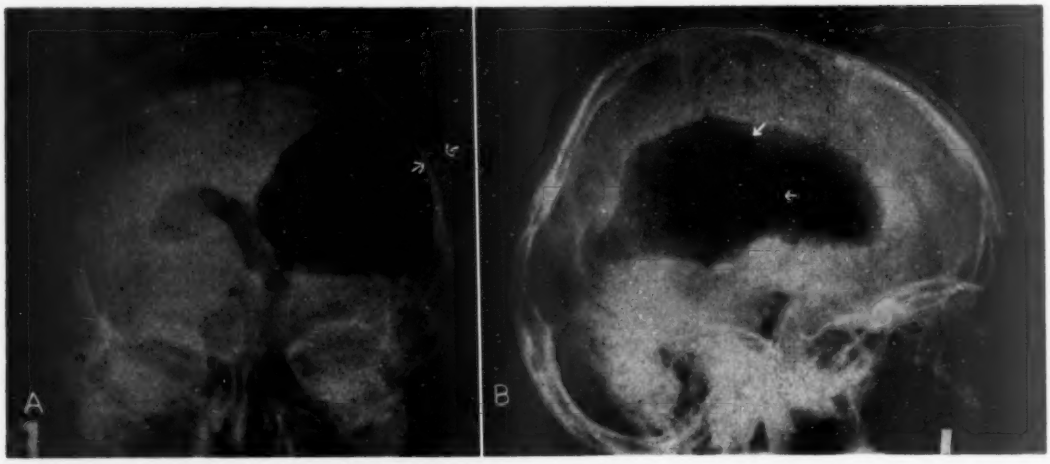


Fig. 2, *A*, *B*, *C*, *D*. Encephalogram of the same patient as shown in Fig. 1, *A* and *B*. These illustrations show a tremendous porencephaly with very little air in the ventricular system and subarachnoid pathways because of incomplete drainage of the cerebrospinal fluid. In (*A*), the posteroanterior view, the falx is shifted to the right; in (*B*), the anteroposterior view, the falx is displaced; in (*C*), the erect lateral view, the fluid level is seen readily and in (*D*), the horizontal lateral view, the extent of the porencephaly can be appreciated. In (*D*) arrows are directed at what may be septa in the cyst.

latter has been stressed in clinical differentiation from Little's disease.[13] Papilledema was present in 3 patients so that a tumor was suspected clinically. Four had homonymous hemianopsia and 1 bitemporal hemianopsia. Peripheral constriction of the visual fields was noted in 1 patient. Patten, Grant and Yaskin[13] describe a "complete syndrome" which they believe is clinically indicative of a porencephalic cyst. It consists of failure of development of one-half or part of one-half of the body, accompanied by motor neuron weakness, sensory disturbances, and jacksonian fits. If the cyst is in a silent area, there may be no symptoms[19] and there are usually relatively few symptoms when one considers the size of the cysts which would often seem incompatible with life. One of our cases, who had no paresis or paralysis and



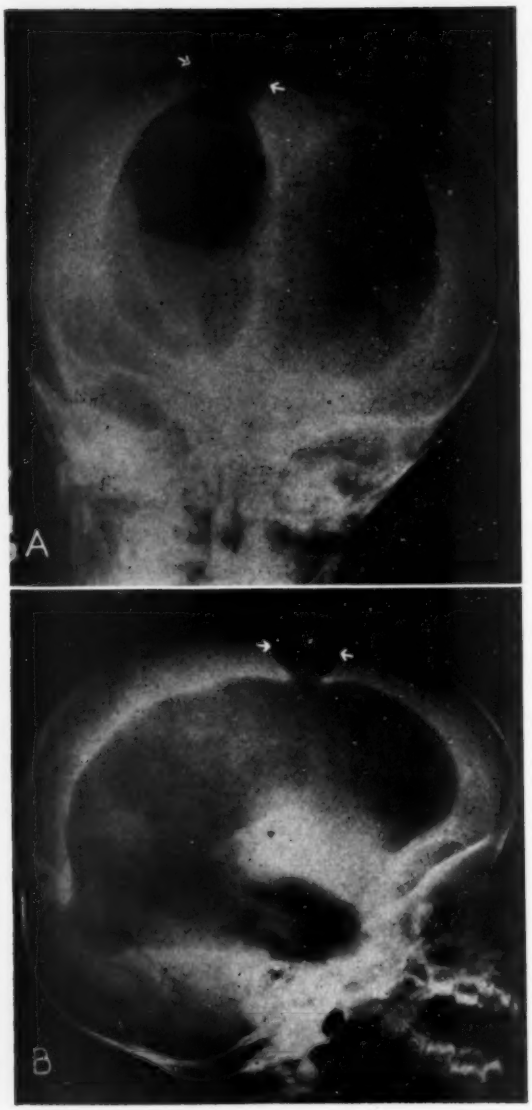


FIG. 3, *A* and *B*. An encephalogram of a male patient, aged fourteen, illustrating a left parietal lobe porencephaly with thickening of the skull in the region of the cyst. In both views the cyst is incorporated in or participated in formation of the shadow of what seems to be an enlarged left ventricle.

complained only of convulsions and diminution of vision, was found to have an extensive porencephaly involving the entire left hemisphere. Nevertheless, as would be expected, the symptoms are to a large extent dependent upon the location of the lesion. Sixteen of this series were left sided, 12 were on the right, and 1 was bilateral. Penfield and Erickson[17] believe the parietal and temporal regions to be the most common site. According to Jaffé,[9] the parietal region is especially exposed to birth injuries. We found the parietal region to be involved wholly or to some extent in 69 per cent, the frontal lobes in 52 per cent, and the occipital lobes in 26 per cent. Three of the patients had more than one cyst.

Conventional roentgenograms may be negative in porencephaly, but more often some degree of asymmetry is evident. The most common finding is a change in the

FIG. 4, *A* and *B*. Small porencephaly in a female child aged two years with extensive internal hydrocephalus.

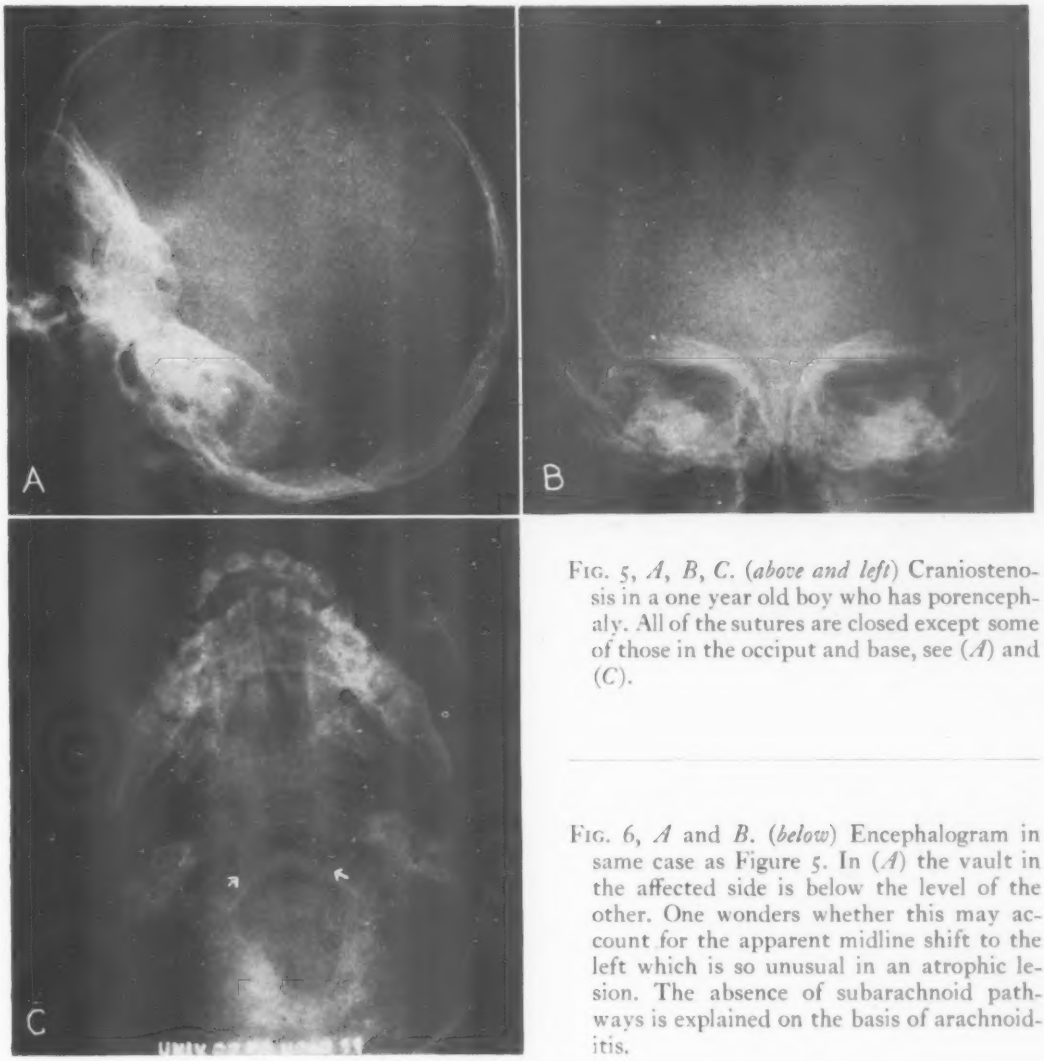


FIG. 5, *A*, *B*, *C*. (*above and left*) Craniostenosis in a one year old boy who has porencephaly. All of the sutures are closed except some of those in the occiput and base, see (*A*) and (*C*).

FIG. 6, *A* and *B*. (*below*) Encephalogram in same case as Figure 5. In (*A*) the vault in the affected side is below the level of the other. One wonders whether this may account for the apparent midline shift to the left which is so unusual in an atrophic lesion. The absence of subarachnoid pathways is explained on the basis of arachnoiditis.

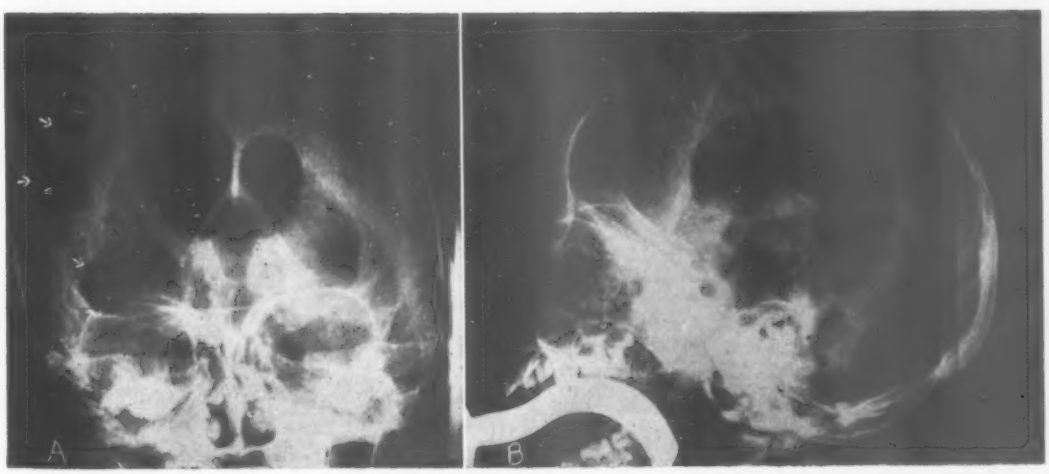


Fig. 7, *A*, *B*, *C*. Calcification in a case of porencephaly in a male, aged twenty-two. The pattern of the calcification is very similar to that seen in some gliomas. Compare with Figure 8. The volume of the skull on the affected side in (*C*) seems greater than on the other. This is unusual in our experience and is difficult to explain in an atrophic lesion.

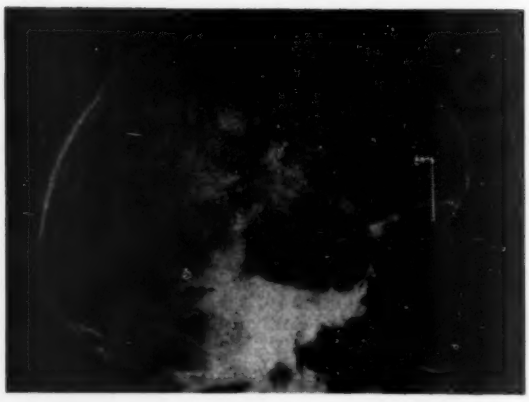


Fig. 8. A male patient, aged forty-six years with calcification in an astrocytoma. Compare with calcification which occurred in patient with porencephaly in Figure 7*A*.

thickness of the skull on one side. This change is usually somewhat localized but may be generalized. Fifteen of this series had some degree of thinning on the side of the lesion (Fig. 1 and 2). The thinning consisted of a localized atrophy in 1 instance (Fig. 13). There was no demonstrable difference in 4 cases, but in 7 the bones were thicker on the homolateral side (Fig. 3). This variation is readily explained in some instances yet in others where similar conditions seem to obtain such an explanation may not be satisfactory. For instance, in those cases with thinning, and in which the cyst is usually in contact with the calvarium and communicating with the ventricle, it is possible for the pulsating intra-

ventricular pressure to be transmitted to the vault through the fluid in the cyst which lies against the bone (Fig. 1 and 2). In cases like that shown in Figure 3, the vault is thicker on the affected side yet the air shadow is adjacent to the bone. Our explanation in this instance is that the atrophic and contracting manifestations of the process (porencephaly) are in preponderance and have thereby stimulated overgrowth of bone.

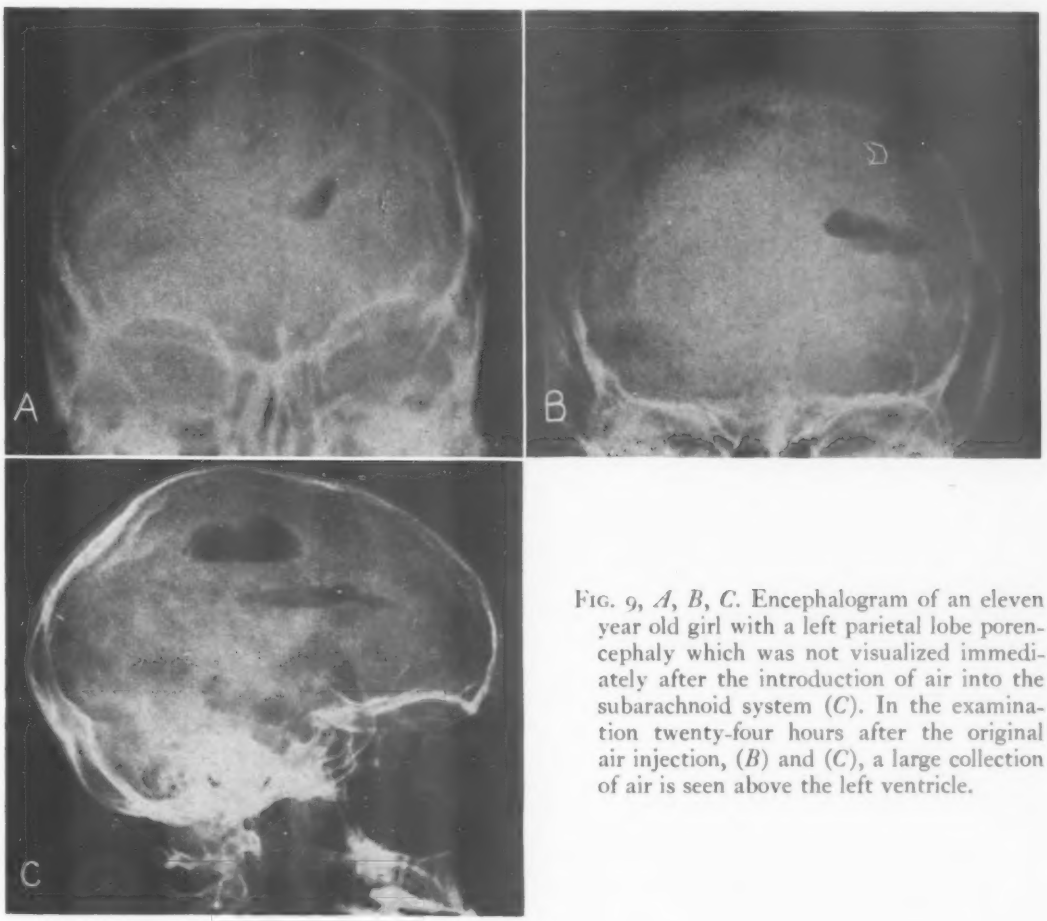


Fig. 9, *A*, *B*, *C*. Encephalogram of an eleven year old girl with a left parietal lobe porencephaly which was not visualized immediately after the introduction of air into the subarachnoid system (*C*). In the examination twenty-four hours after the original air injection, (*B*) and (*C*), a large collection of air is seen above the left ventricle.

Porencephaly is a manifestation of atrophy and it may be the underlying lesion in hemiatrophy or underdevelopment. In such a case, the cranial vault on the affected side may be smaller, and there may be a *thickening or compensatory hypertrophy of the bones, elevation of the petrous ridge, and increased pneumatization of the petrous pyramid, mastoid and frontal and ethmoid sinuses*, any or all of which may be present on the side of the porencephaly. Similar observations have been made by Davidoff and Dyke[3] in chronic relapsing subdural hematoma. Thus, if the element of atrophy predominates, there may be homolateral thickening of the bones but it does not mean necessarily that other manifestations of hemiatrophy will be present. Slightly more than 50 per cent of the series had no variation in skull volume. The volume of the skull on the side of the lesion was definitely less in 6 cases. A significantly greater volume was noted in only 1 case (Fig. 7).

Occasionally in patients with porencephaly one may find a co-existing hydrocephalus or craniostenosis (Fig. 4, 5 and 6). If the pineal is calcified, it is more often

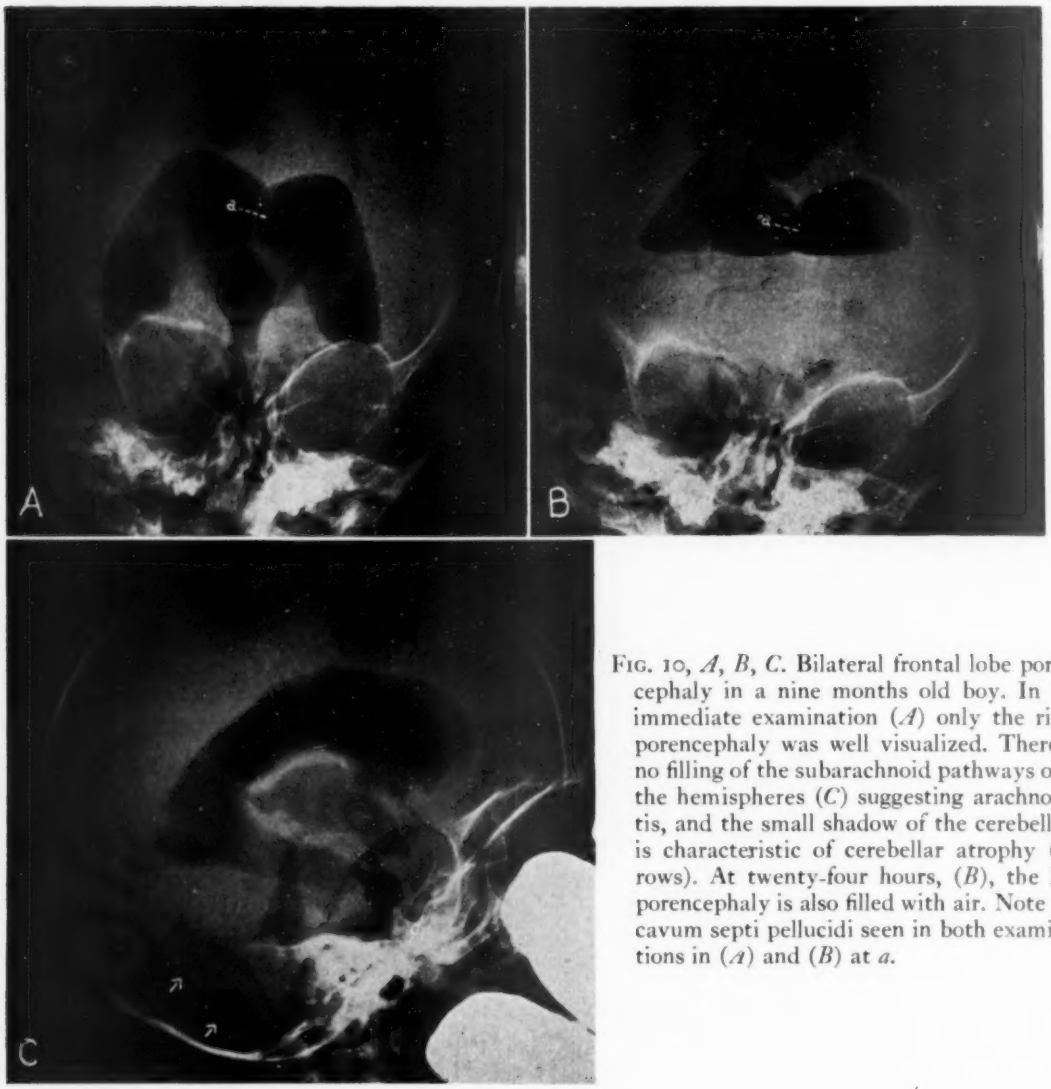


Fig. 10, *A*, *B*, *C*. Bilateral frontal lobe porencephaly in a nine months old boy. In the immediate examination (*A*) only the right porencephaly was well visualized. There is no filling of the subarachnoid pathways over the hemispheres (*C*) suggesting arachnoiditis, and the small shadow of the cerebellum is characteristic of cerebellar atrophy (arrows). At twenty-four hours, (*B*), the left porencephaly is also filled with air. Note the cavum septi pellucidi seen in both examinations in (*A*) and (*B*) at *a*.

but not always slightly displaced toward the side of the lesion because of the accompanying cerebral atrophy. Furthermore, there may also be *calcification* in the region of the porencephaly. This has not been previously reported but in 1 of our cases, there was a *calcification not unlike that seen in gliomas* (Fig. 7 and 8).

A definite diagnosis of porencephaly can be made only by the use of encephalography or ventriculography and since the development of these two procedures, what was thought to be a rare condition is found much more frequently. Encephalography also may demonstrate accompanying changes such as arachnoiditis (Fig. 6 and 10), convolutional atrophy (Fig. 16), enlargement of the basal cisternae (Fig. 11), and anomalies such as cerebellar atrophy (Fig. 10). Pendergrass and Hodes[14] have demonstrated the value of the twenty-four hour examination in showing porencephaly not evident in the roentgenographic examination immediately following the injection of the air into the lumbar subarachnoid space. An unsuspected porencephaly was discovered in 1 of our cases at twenty-four hours (Fig. 9), and an additional porencephaly in the opposite cerebral hemisphere was demonstrated in another (Fig.

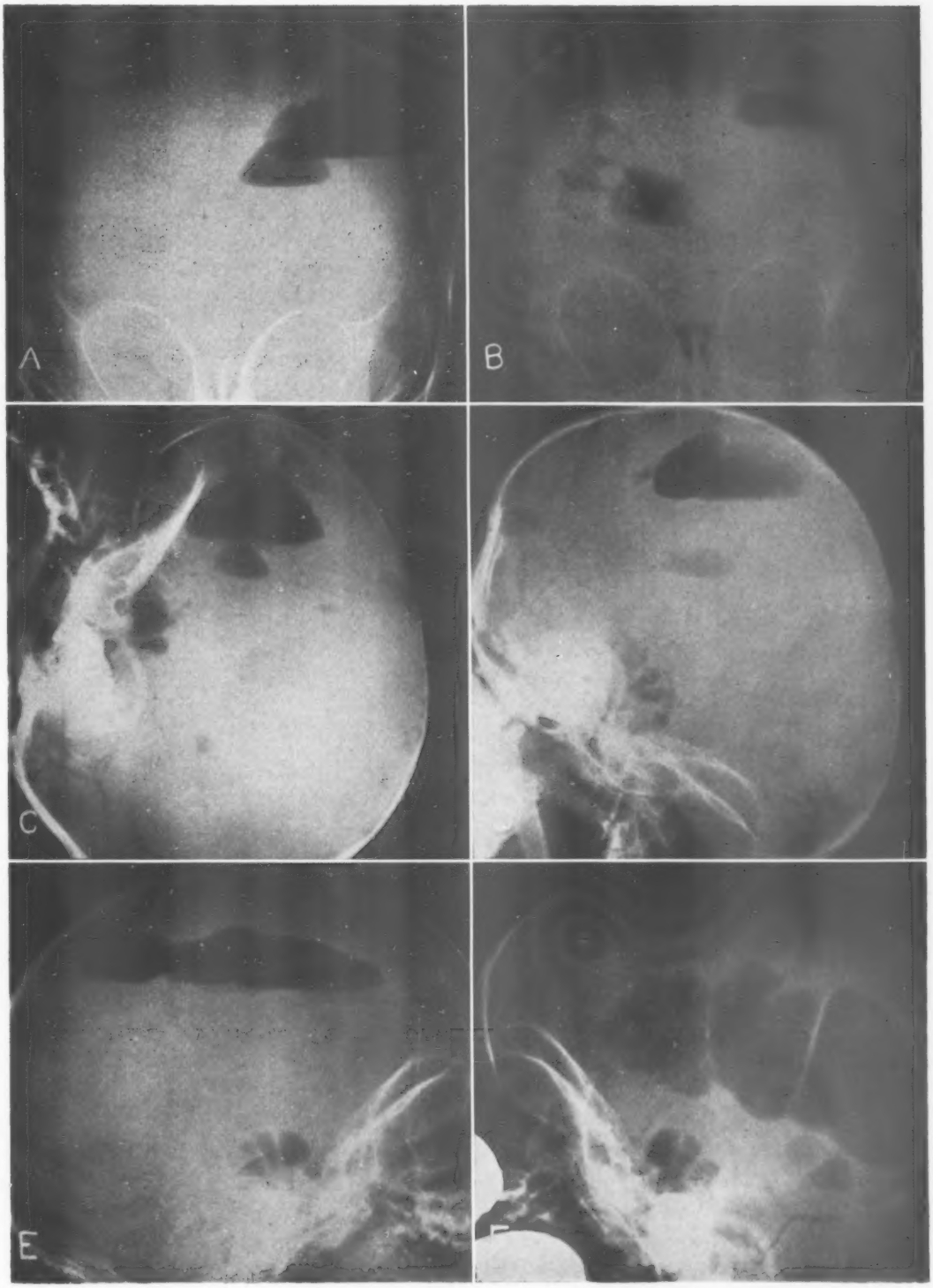


FIG. 11, *A*, *B*, *C*, *D*, *E*, *F*. (*A*) represents porencephaly in the left hemisphere in a nine months old boy. Only the left ventricle can be seen. In (*B*), examination twenty-four hour after (*A*), the right ventricle contains air. When the ventricular system is incompletely drained, roentgenograms obtained in the horizontal position, supine (*C*) and prone (*D*) assist greatly in determining the extent of the porencephaly.

In (*E*) and (*F*), the basal cisternae in the region of the sella seem large. (*E*) was obtained in the erect posture and (*F*) in the horizontal. The absence of subarachnoid cortical air may be due to arachnoiditis or to incomplete drainage of fluid.

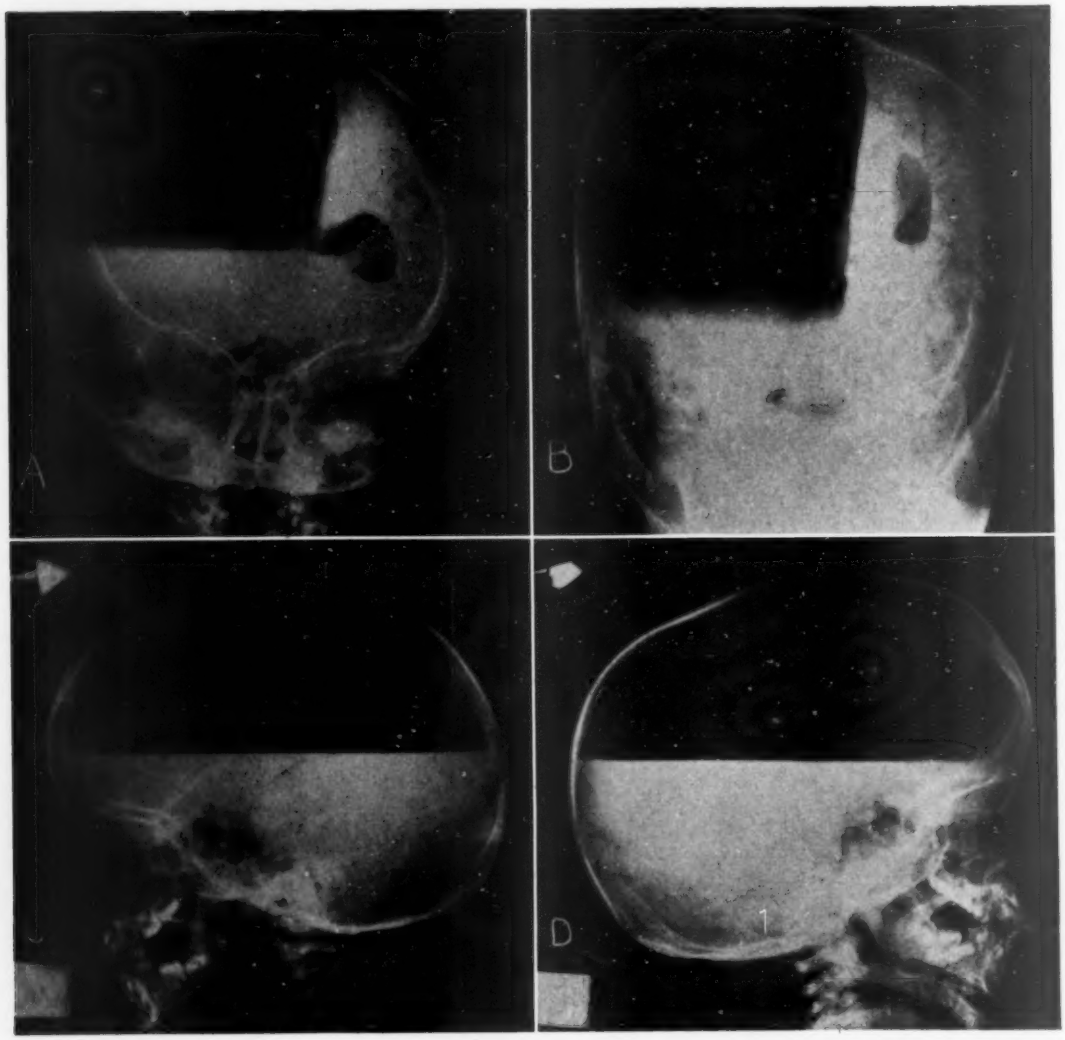


Fig. 12, *A, B, C, D.* A ventriculo-encephalogram in a twenty months old female child illustrating a large porencephaly replacing the right hemisphere. The various positions employed to demonstrate the walls of the porencephaly are shown.

(*A*) posteroanterior view; (*B*), anteroposterior; (*C*) right lateral, erect; (*D*) left lateral, erect.

10). Furthermore, if only one ventricle has been visualized initially, the opposite one may be filled in the twenty-four hour examination (Fig. 11).

Ventriculography is preferred in the occasional case with increased intracranial pressure. Occasionally the needle employed to drain the ventricles may enter a noncommunicating porencephaly which otherwise may not be demonstrable by either encephalography or ventriculography.

It is often difficult to demonstrate satisfactorily the true extent of the porencephaly, especially if there has been incomplete drainage of the cerebrospinal fluid prior to the injection of the air. Regardless of which air study is used, the examination should include the following positions as a minimum: (1) posteroanterior and anteroposterior views; (2) each lateral erect, stereo preferred; (3) each lateral in the prone position using a vertical beam; (4) a single lateral in the supine position (brow up) and a single lateral in the prone position

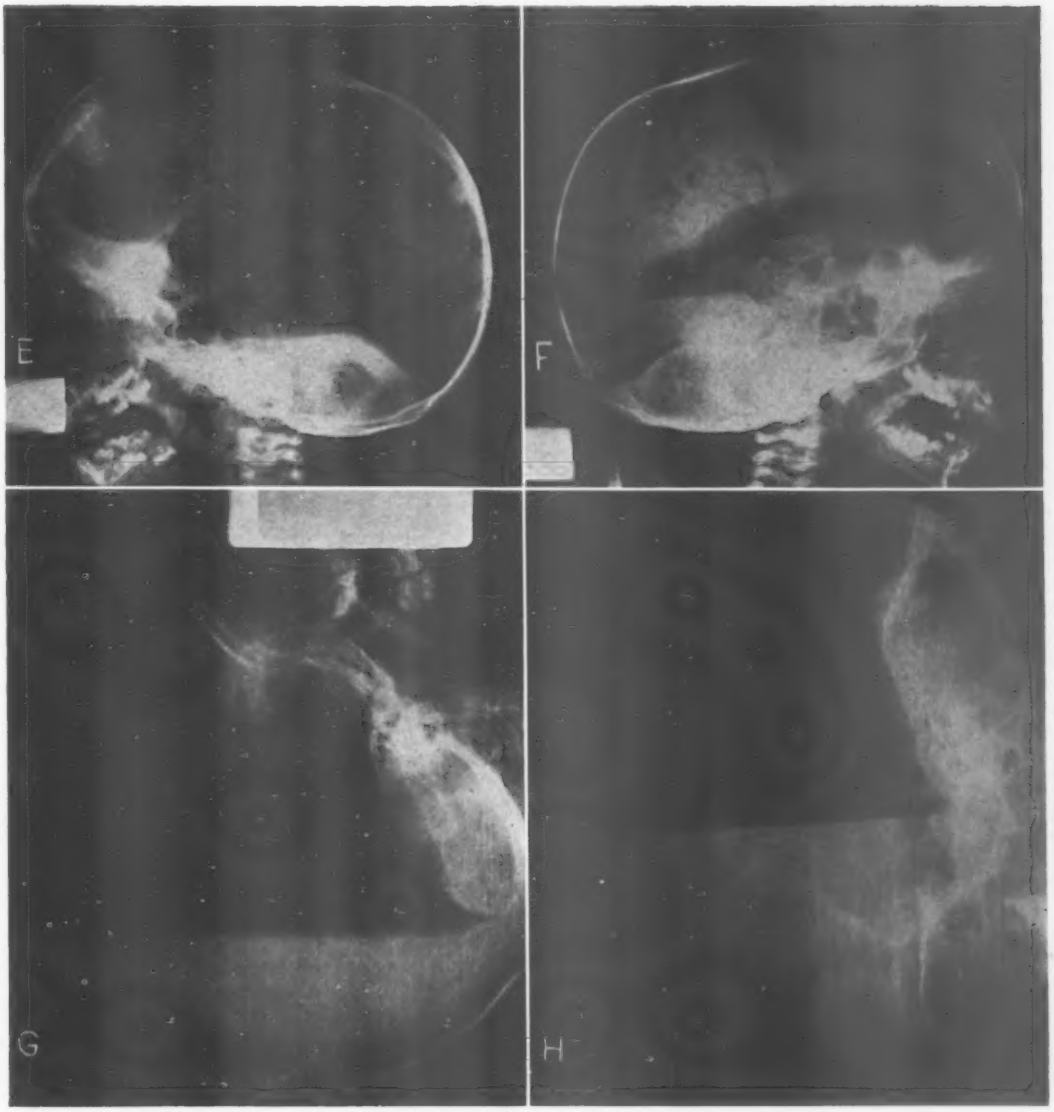


Fig. 12, *E, F, G, H.* (*E*) right lateral, horizontal; (*F*) left lateral, horizontal; (*G*) lateral horizontal, supine; (*H*) lateral horizontal, prone.

(brow down) using a horizontal beam. If drainage is of necessity incomplete, further views may be necessary to outline the entire wall of the porencephaly and to demonstrate undrained daughter cysts in the porencephaly (Fig. 12, *A–K*). These are usually made in the posteroanterior projection using a horizontal beam with the patient lying on either side. Another posteroanterior and lateral should be made with the patient's head hanging downward (inverted position) to outline the floor of the cyst (Fig. 12, *A–K*).

Roentgenologically, there are several types of porencephaly. The terms "lobe," "interlobe," and "hemisphere" porencephaly may be used as an anatomical classification indicating location and size. The majority of the porencephalies are either "lobe" (48 per cent) (Fig. 13, *A–B*), or "interlobe" (41 per cent) (Fig. 14, *A–B*), consisting of medium-sized and large cysts with smooth well demarcated walls. The exact location of the communication with

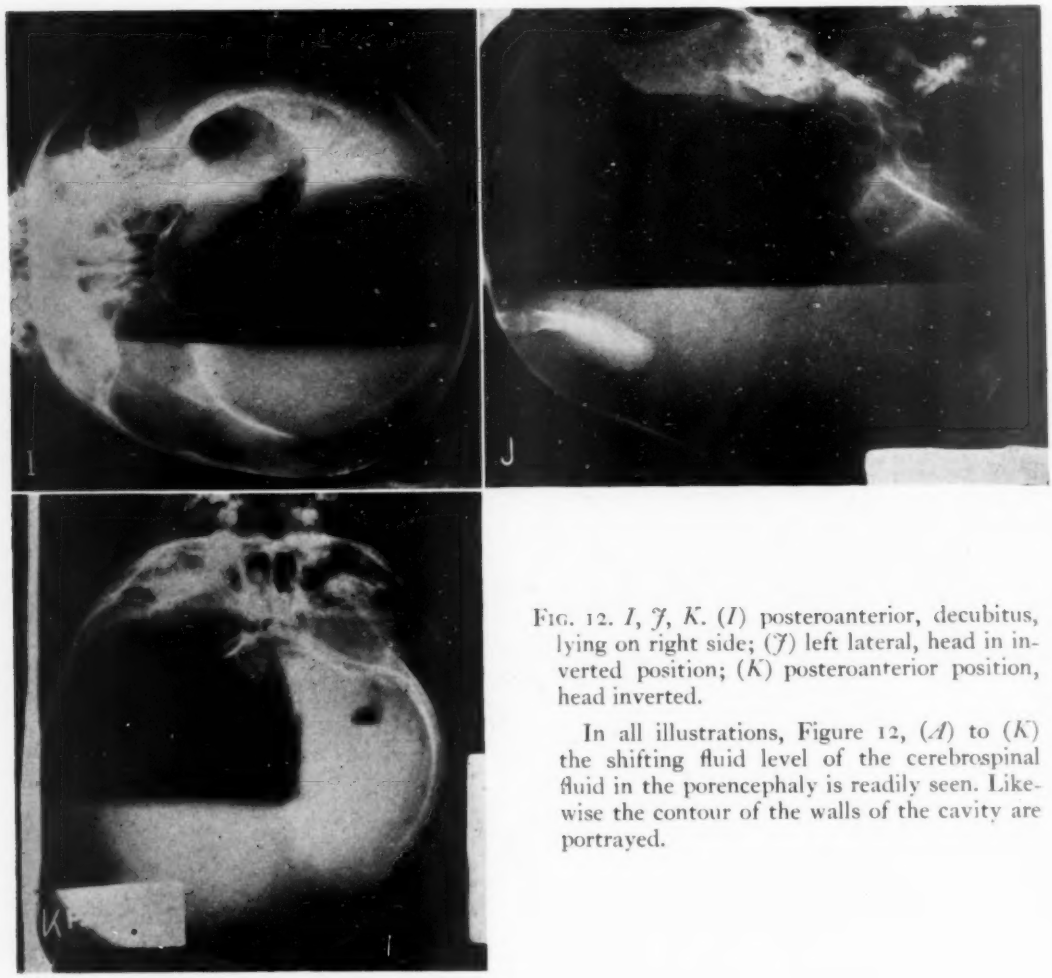


Fig. 12. *I*, *J*, *K*. (*I*) posteroanterior, decubitus, lying on right side; (*J*) left lateral, head in inverted position; (*K*) posteroanterior position, head inverted.

In all illustrations, Figure 12, (*A*) to (*K*) the shifting fluid level of the cerebrospinal fluid in the porencephaly is readily seen. Likewise the contour of the walls of the cavity are portrayed.

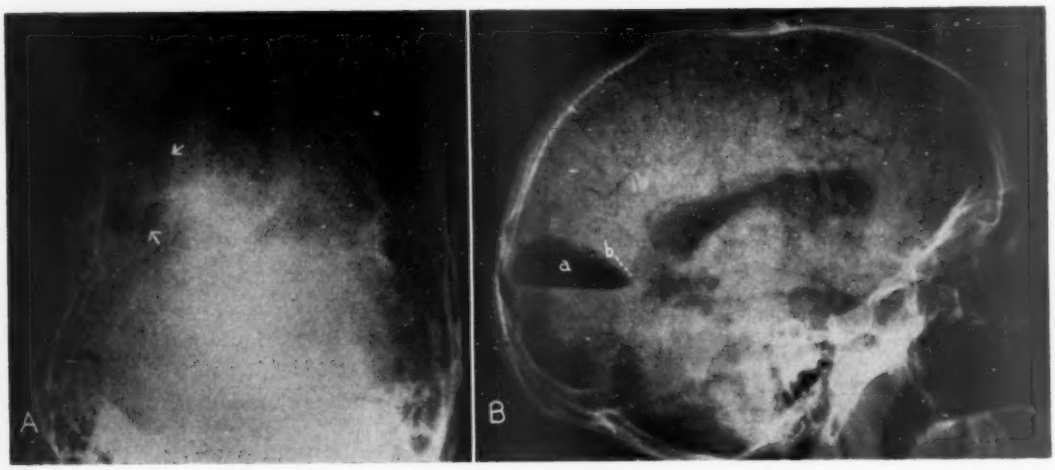


Fig. 13, *A* and *B*. Right occipital lobe porencephaly in a male aged nineteen years. In (*A*) the localized area of bone atrophy is seen in the occipital bone, overlying the porencephaly. In (*B*) the porencephaly communicates with the posterior horn of the lateral ventricle at *b*.

the ventricle is often difficult to demonstrate and may not be seen but if sufficient views are obtained one frequently can demonstrate its site (Fig. 14). Rarely, one may see a cluster of "daughter" cysts on the wall of the large "mother" cyst, simulating the nubbin of a cystic glioma, (Fig. 24). Occasionally a few rather large septa may be seen extending across the porencephaly (Fig. 2*D*).

There is a small group of lobe porencephaly in which the cyst is small, very irregular in outline, and may contain septa and diverticula or pseudopodia-like extensions (Fig. 6 and 15). Trauma is usually the suspected etiologic agent in this group. One of our patients (Fig. 16) had an unusual bone lesion, overlying the brain lesion, which was believed to be traumatic in origin. More rarely one may encounter lobe porencephaly in hydrocephalus. The porencephaly is small, unilateral or bilateral, and has an unusually narrow communication with the lateral ventricle (Fig. 4).

Hemisphere porencephaly is rather unusual and had an incidence of only 7 per cent in this series. Here the cavity is tremendous, smooth and regular in outline, and largely limited by the calvarium. The entire hemisphere is replaced by the cyst (Fig. 2 and 11). Complete drainage of the cerebrospinal fluid is rarely obtained and it may be difficult to demonstrate the lateral ventricle. As may be suspected this condition is occasionally difficult to differentiate from unilateral hydrocephalus.

Only 1 case of "closed" porencephaly occurred in this series. In this type the cyst is separated from the ventricle by a thin membrane and does not communicate with the subarachnoid space (Fig. 23). This type of lesion may, according to Penfield and Erickson,[17] be caused by cerebral thrombosis or embolism. They believe the cyst remains closed because the ependymal wall of the ventricle is more resistant to anoexmia than the adjacent cerebral tissue.

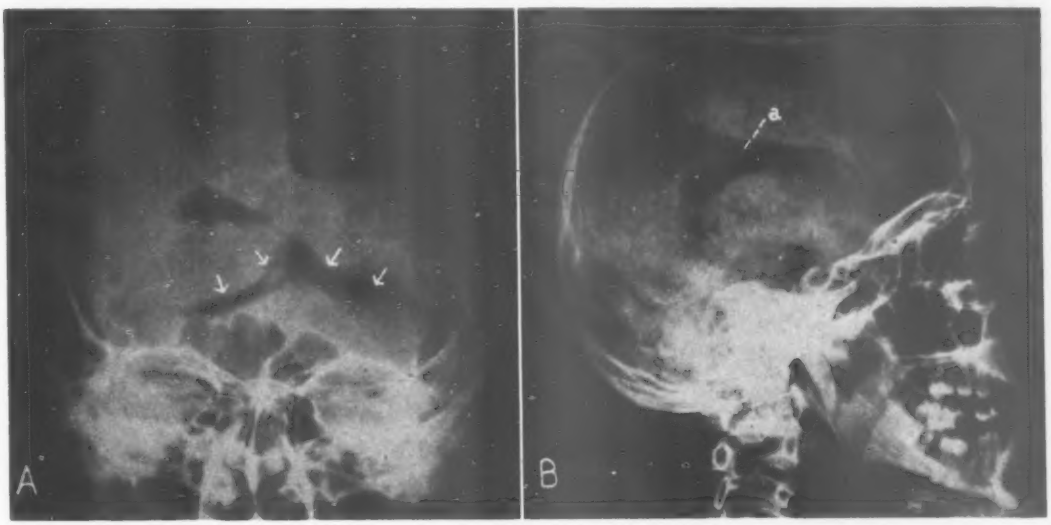


Fig. 14, *A* and *B*. (*A*) encephalogram of a twenty-four year old male with a left parietal lobe porencephaly. The falx and tentorium are displaced toward the air-filled cyst. The tentorium is outlined by the subdural air beneath it (arrows). (*B*) the communication of the porencephaly with the ventricle was demonstrated only in the lateral view and can be seen at *a*.

Since porencephaly is an atrophic process, one would expect other manifestations of cerebral atrophy. Two-thirds of the group had other evidence of cortical or subcortical atrophy such as enlarged lateral ventricles or increase in the size of the subarachnoid pathways. The enlargement of the lateral ventricle may be localized or

general and is usually unilateral and homolateral. Not infrequently, there is bilateral enlargement and rarely there is greater enlargement of the lateral ventricle on the opposite side (Fig. 17). Arachnoiditis may be an accessory factor in the production of hydrocephalus in some of the cases. A localized arachnoiditis is usually found overlying the cyst, and occasionally there is a generalized loss of subarachnoid pathways and obscuring of the basal cisternae. If one can be sure that complete or adequate drainage of the cerebrospinal fluid has been secured, one is justified in making a diagnosis of arachnoiditis (Fig. 6). The literature[4,17] gives one the impression that arachnoiditis is found only on the side of the porencephaly. We found diffuse bilateral arachnoiditis, or at least an absence of subarachnoid pathways, to be more common that unilateral arachnoiditis. Not infrequently there is evidence of arachnoiditis only over the opposite hemisphere. A slight shift of the ventricles is usually present (88 per cent) and more often the shift is toward the porencephalic side because of the accompanying atrophy. There may be little shift even in the presence of large cysts

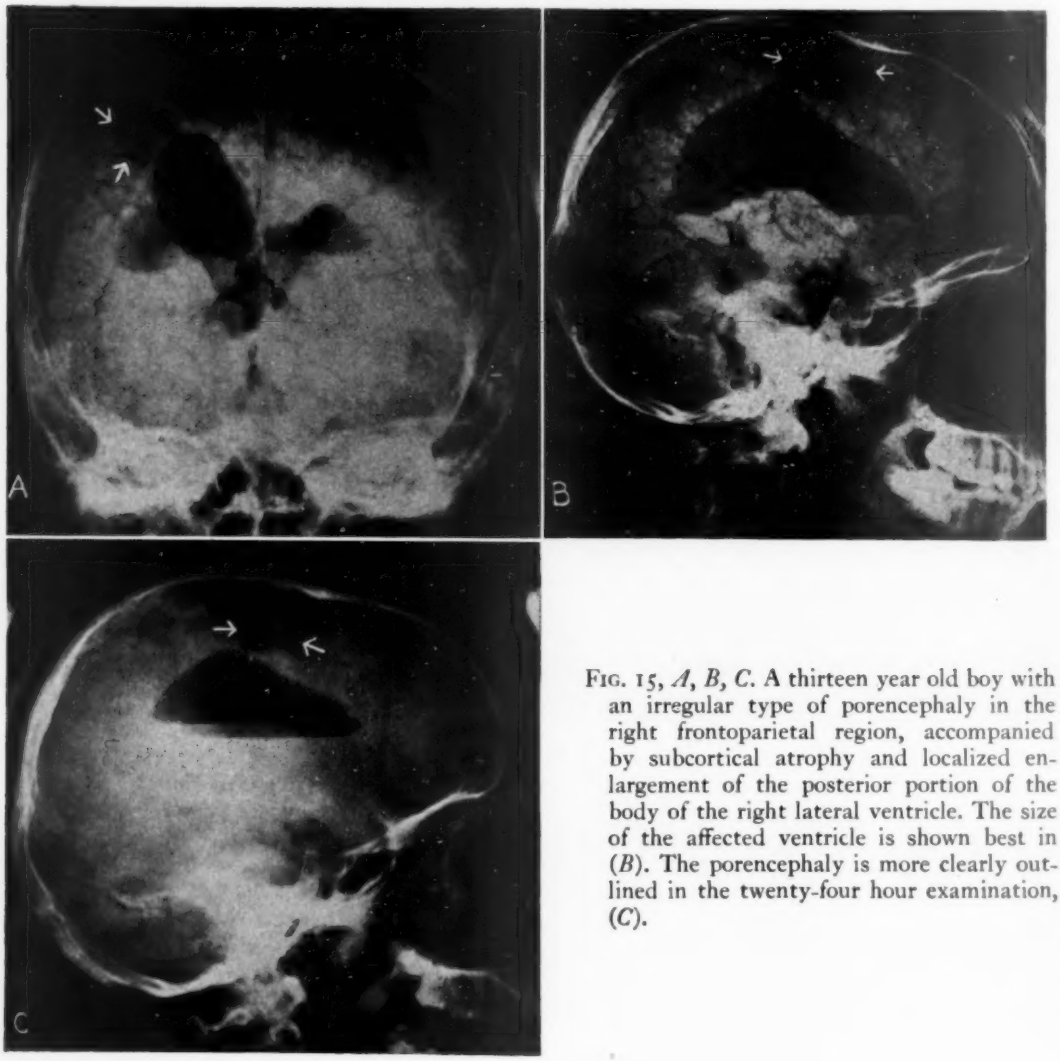


Fig. 15, *A, B, C.* A thirteen year old boy with an irregular type of porencephaly in the right frontoparietal region, accompanied by subcortical atrophy and localized enlargement of the posterior portion of the body of the right lateral ventricle. The size of the affected ventricle is shown best in (*B*). The porencephaly is more clearly outlined in the twenty-four hour examination, (*C*).

(Fig. 19). Contrary to the usual conception, there was displacement toward the opposite side in 10 instances. An adequate explanation is not always possible, but such a condition may be produced by the pressure of the cyst or greater atrophy of the opposite hemisphere (Fig. 3 and 18). In 1 patient there was bulging of the skull and displacement of the falx to the opposite side by the porencephaly and possible displacement of the third ventricle to the homolateral side (Fig. 18). The atrophy may be of such an extent that the tentorium is displaced upward. This is seen only if a portion of the injected air is subdural and beneath the tentorium (Fig. 14). Other associated findings may include cerebellar atrophy (Fig. 10) and abnormalities of the septum pellucidum. Perforation of the septum pellucidum was found twice and cavum septi pellucidi twice (Fig. 10). LeCount and Semerak[11] found the corpus callosum to be absent in 1 of their cases.

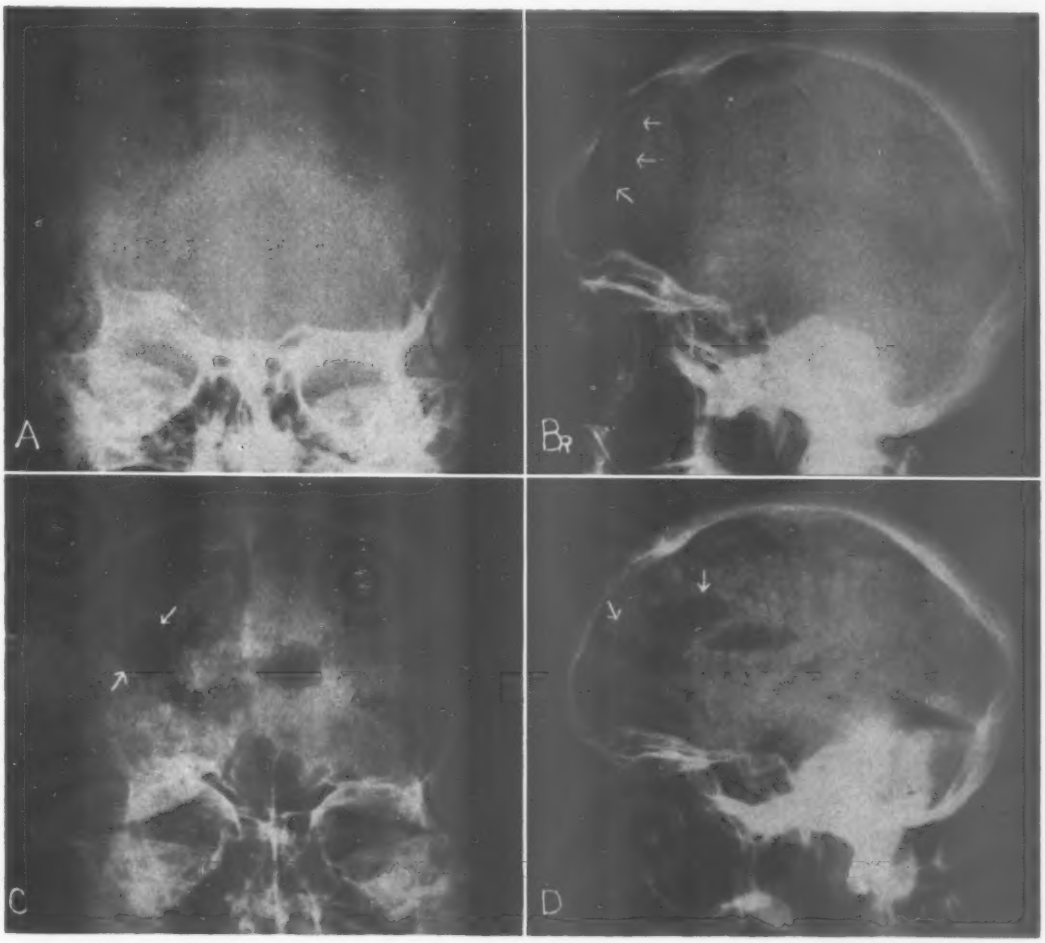


Fig. 16, *A, B, C, D.* An irregular right frontal lobe porencephaly in a twenty year old man. In (*A*) and (*B*) an unusual osteolytic process can be seen in the right frontal region. In (*C*) and (*D*) the porencephaly is in the frontal region. There is some midline shift of the falx toward the affected side.

In many cases the diagnosis of porencephaly is not as simple as one would suspect. Either porencephaly or focal atrophy or both may follow localized contusion or laceration of the brain. According to Foer-

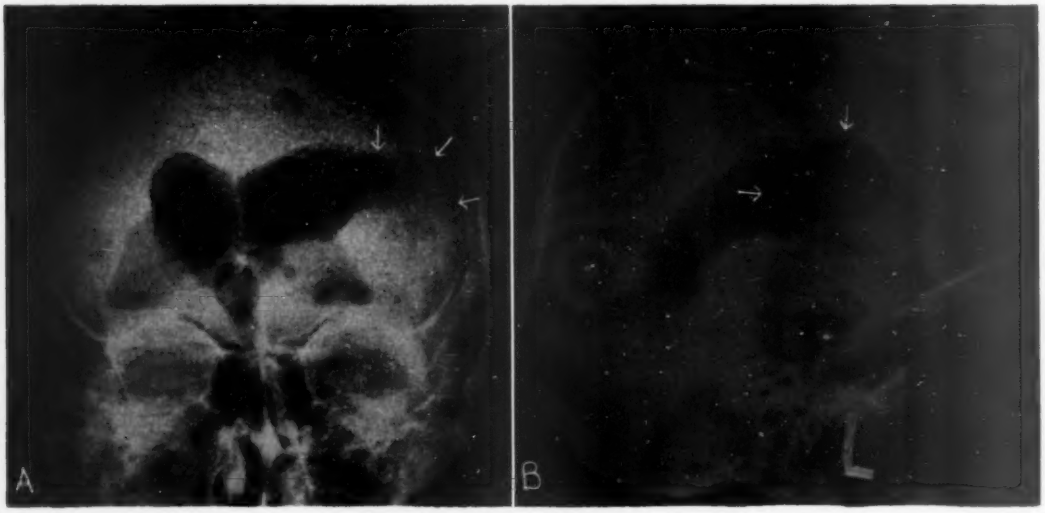


FIG. 17, *A* and *B*. Left frontal lobe porencephaly in a thirty-four year old male with no history of trauma. The right lateral ventricle is slightly larger than the left, seen best in (*A*).

ster and Penfield[7] the patient may not develop symptoms for as long as fourteen years after the injury. With the development of focal atrophy the adjacent ventricular wall tends to migrate out toward the area. If a cyst has formed there is less migration.[17] When the ventricular "diverticulum" has migrated to the meninges and has enlarged, it becomes exceedingly difficult to draw a line of differentiation between this and porencephaly (Fig. 17 and 22). As in 1 of our cases (Fig. 17), the absence of a history of trauma may be of some aid in this differentiation. Porencephaly may be difficult to differentiate from nontraumatic subcortical atrophy with dilatation of a portion of the lateral ventricle (Fig. 20). The variable posterior horn of a large ventricle must not be confused with porencephaly (Fig. 21). It may also be ac-

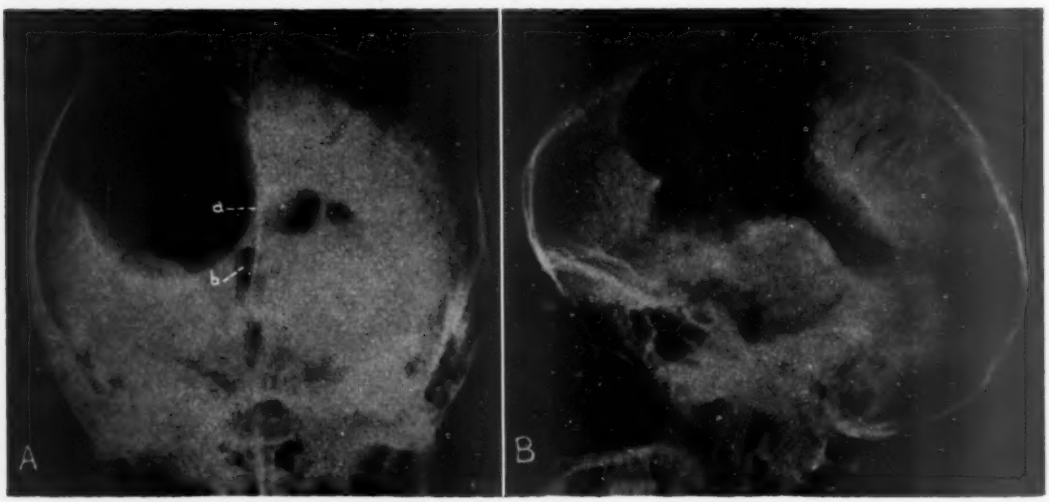


FIG. 18, *A* and *B*. A girl, aged fourteen, with a right frontal porencephaly. In (*A*) the vault on the right side is higher than the left, the falx is displaced to the left at *a* superiorly. The third ventricle, *b*, is in the midline or tilts slightly to the right. In (*B*) the large circular porencephaly is seen to good advantage.

companied by a marked localized cortical atrophy with patchy arachnoiditis (Fig. 15), and the enlarged cortical pathways themselves may in some areas simulate porencephaly. Reavis and Kilby[19] believe an air-filled subdural hematoma cyst may be confused with porencephaly. This has not occurred in our experience.

The differentiation of hemisphere porencephaly (Fig. 2, 11 and 12) from extensive unilateral hydrocephalus in which the ventricle has been incompletely drained may be most difficult. Conventional roentgenograms in the hydrocephalic child are more likely to show enlargement or bulging of the skull. Sufficient drainage of the cerebrospinal fluid must be obtained to demonstrate the characteristic ventricular contour in unilateral hydrocephalus (Fig. 12). In most instances filling of the ventricle as well as the porencephaly is discernible in the posteroanterior and anteroposterior projections. The twenty-four hour examination may reveal a previously unfilled ventricle. If the ventricle is not demonstrable the porencephaly may be sufficiently filled to reveal its extent and rule out the possibility of its being only an enlarged ventricle.

Malignant gliomas are the most important lesions to be differentiated from porencephaly. Calcification in the wall of the cyst may simulate that seen in malignant gliomas or tuberculomas (Fig. 7 and 8). Occasionally the gliosis in the wall of the porencephaly may be confused microscopically with tumor tissue.

CASE REPORTS

Case 1. A nineteen year old boy was admitted on July 24, 1934, complaining of convulsions for seven years. He had had a right hemiparesis since infancy. In 1927 an exploratory craniotomy was performed revealing a very extensive subarachnoid cystic accumulation just behind the left rolandic fissure. Strips of celloidin tissue were placed beneath the arachnoid to provide drainage of the subarachnoid space. He was subsequently followed in the clinic, showing little improvement. On readmission in 1932, an encephalogram was done, revealing cortical atrophy or scar formation in the left parietal region. The left lateral ventricle was larger and extended laterally further than the right (Fig. 22). Following this his convulsions continued, becoming slightly more severe prior to readmission. Another encephalogram following readmission on July 10, 1934, revealed enlargement of the localized area of dilatation of the left lateral ventricle. On August 10, 1934, the craniotomy site was again exposed. The dura was thickened and there were many adhesions, some vascular, between the dura and cortex Scar tissue ran down along the sylvian fissure and the ventricle came to the surface in the middle of the supramarginal gyrus. The scar along the sylvian fissure and the thickened wall of the porencephaly were dissected free, excessive vascularity being noted. Three days postoperatively he became stuporous and died.

Microscopic Report of Specimen: "The tumor is very cellular and very fibrillar. The cells run

Fig. 19. Encephalogram of a twenty-two year old woman with a large left interlobe parieto-occipital porencephaly showing little if any displacement of the midline structures.

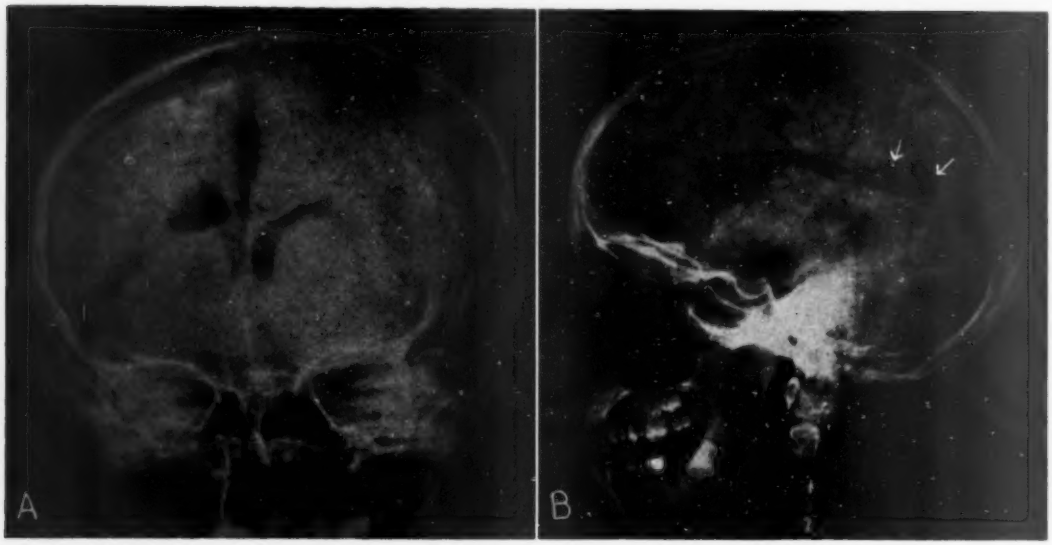


Fig. 20, *A* and *B*. A sixteen year old girl with an air-filled cavity in the right parieto-occipital region. The appearance could be that of a subcortical atrophy with localized dilatation of the posterior portion of the lateral ventricle, or it could be a porencephaly which has been incompletely visualized.

in many different directions in streams which penetrate here and there. There are many vessels. Fibrous stroma is scanty. There are large numbers of long, wavy, hard fibrils which run in parallel bands and which are particularly dense around the blood vessels. The cells have oval vesicular nuclei. There are no mitoses. Diagnosis: Astrocytoma."

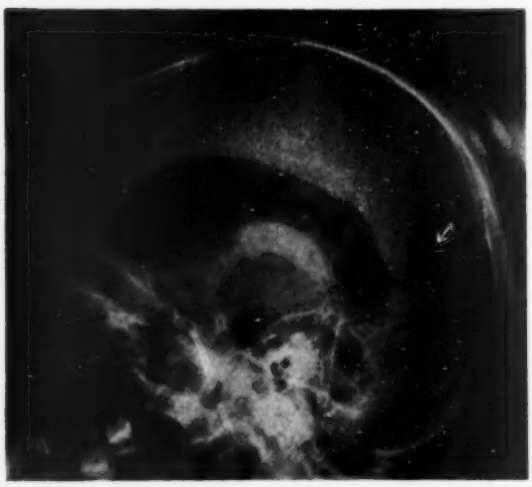


Fig. 21. A partially filled posterior horn of the lateral ventricle which does not represent porencephaly. The posterior horn air shadow frequently does not communicate with the air shadow of the body of the ventricle. This we believe is due to incomplete drainage of the cerebrospinal fluid.

Comment. This case was clinically and roentgenologically undoubtedly a traumatic lobar porencephaly. The slide and history were recently presented to Dr. Bernard J. Alpers, Professor of Neurology, Jefferson Medical College. His report was as follows: "If I did not have the history and were asked to make a diagnosis on the basis of the specimen alone, I should be forced to call it an astrocytoma. In view of the history, however, I am forced to regard it as a severe degree of gliosis. It serves as an example of the difficulty that may exist in making a clear cut distinction between gliosis and tumor, and in this instance the glial overgrowth is so great that it has the typical appearance of an astrocytoma."

Strom-Olsen[20] and Jaffé[9] and others have described exaggerated gliosis and membranes of fibrillar glia separating the cysts from the white matter. The wall of the cyst itself may consist of an outer connective tissue layer and an inner layer of fibrillary glia which in places swell up into cellular plaques, containing may dark brown and yellowish brown pigment granules (Jaffé).[9] It is readily understandable that in instances such as this the microscopic appearance may be most confusing and must

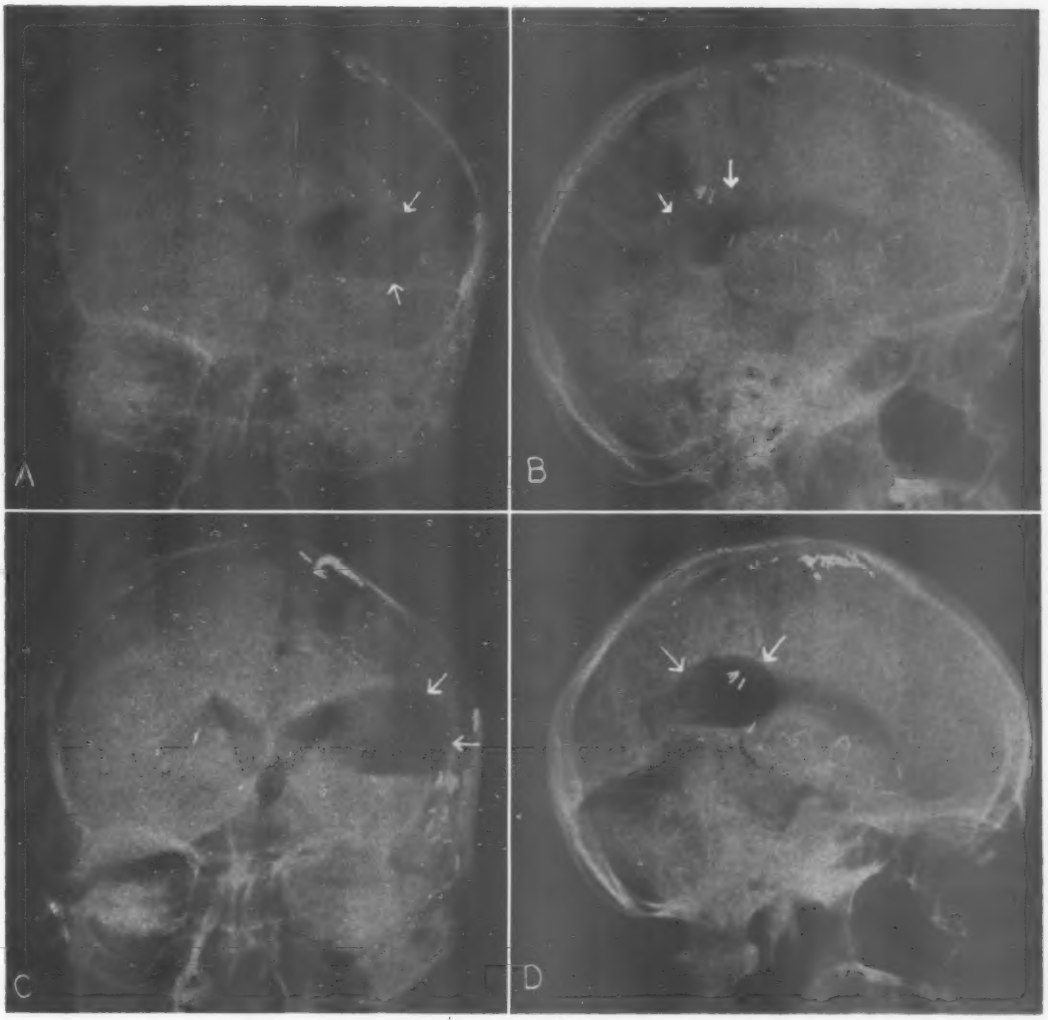


Fig. 22, *A*, *B*, *C*, *D*. Case 1. Encephalogram of a seventeen year old boy with a postoperative ventricular diverticulum in the left parieto-occipital region, (*A*) and (*B*). The walls of the process continued to migrate to the periphery until it became a porencephaly two years later, (*C*) and (*D*).

be interpreted in the light of the clinical findings. This case (Fig. 22) also serves to illustrate the development of a porencephaly following possible birth injury and the trauma of a craniotomy. The appearance is not unlike "the migrating ventricle" following penetrating wounds.[17]

Case II. A twenty-eight year old white female was admitted to the Neurosurgical Service complaining of weakness in the left leg for one and one-half years. Weakness of the left arm began eight months before admission. Right facial numbness and weakness had been present for three months. Physical examination revealed a hyperesthesia of the right face and scalp, left hemiparesis with hyperactive reflexes, left Babinski sign, and bilateral papilledema OD = 5 diopters, OS = 4 diopters. Plain roentgenograms of the skull revealed a slight increase in the prominence of the digital markings and erosion of the dorsum sella. A preoperative ventriculogram revealed a mass lesion in the right frontoparietal region, causing marked ventricular distortion and displacement of the midline structures and ventricle to the left (Fig. 23).

On the second day of admission a right frontotemporal parietal craniotomy was performed. The dura showed no abnormalities, but yellowish discoloration involved the upper post

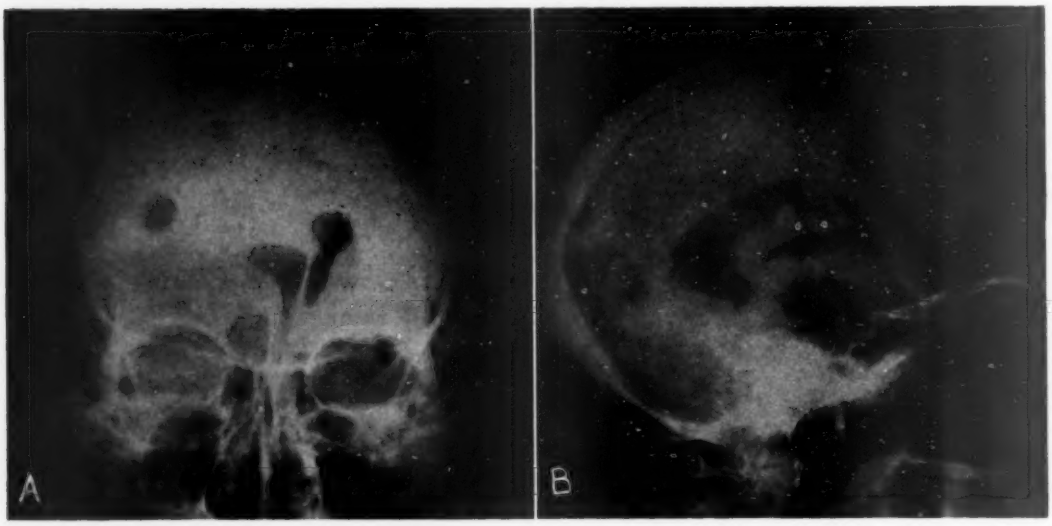


Fig. 23, *A* and *B*. Case II. A right frontoparietal "closed" porencephaly in a woman aged twenty-nine, causing marked ventricular shift and distortion. The appearance cannot be differentiated from that of other mass lesions. Note the thinning of the dorsum sellae.

central gyrus and motor cortex. Clear fluid was aspirated from this region. A transcortical incision exposed a large cyst about 3 inches in diameter, bordered by the falx medially. The wall was soft and slightly yellowish. At no point was there a nubbin of tumor. A communication with the ventricle could not be demonstrated. It seemed that the lesion in all probability was a porencephalic cyst. Five small pieces of tissue were removed from the wall of the cyst.

Microscopic Report of Specimen: "The tissue represents the covering layer of a cortical cyst. It contains a number of nerve cells, irregularly distributed, and fairly large glia nuclei without glia fibre formation. Diagnosis: Porencephalic cyst."

Comment. Various authors[4,13,19] have

Fig. 24, *A* and *B*. Case III. Porencephaly in the left frontal region of a thirty-one year old male. In (*A*) there is a soft tissue shadow occupying the anterolateral aspect of the air filled porencephaly that looks very much like a nubbin of a glioma (see Fig. 27). The falx is displaced to the right at *a*. In (*B*), the daughter cyst can be seen in the lateral view.

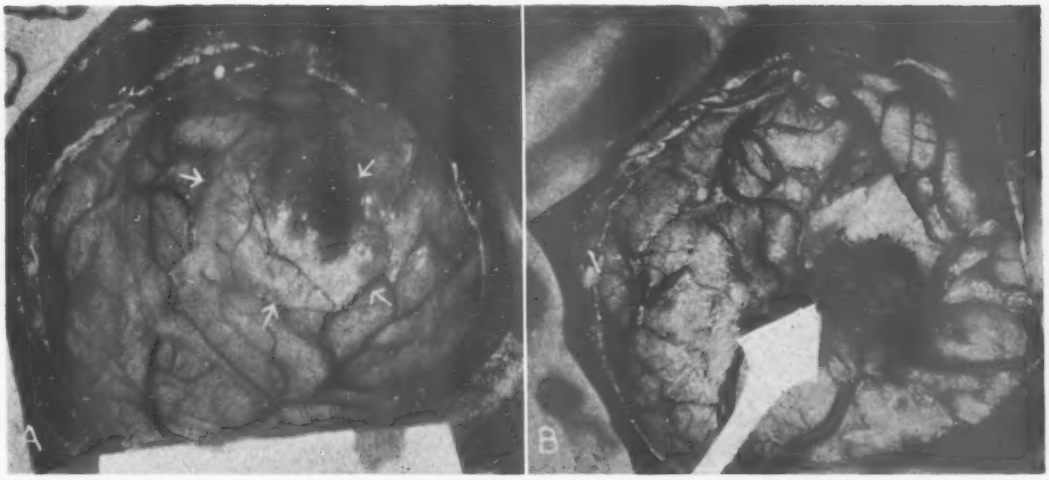


Fig. 25, *A* and *B*. Same case as Figure 24. In (*A*), one can see the appearance before operation on the cyst. In (*B*) the roof of the cyst has been removed showing the extent of the lesion.

stated that porencephaly may be differentiated from gliomatous cysts by the lack of atrophy, encroachment on, rather than dilatation of the ventricle, and the displacement of the ventricles to the opposite side. Reavis and Kilby[19] further state that gliomatous cysts generally do not communicate with the ventricle. It is readily apparent that this case of closed porencephaly embodies all the characteristics of a mass lesion and cannot clinically or roentgenologically be differentiated from other mass lesions such as a brain tumor.

Case III. A thirty-one year old white male was admitted complaining of frontal headaches of increasing severity for six months. He had vomited on five occasions without nausea. Forgetfulness and trance-like states subsequently were noted, and for three weeks there had been blurring of vision in the left eye. Examination revealed a decrease in the sense of smell on the left, bilateral papilledema, 4 diopters, slight

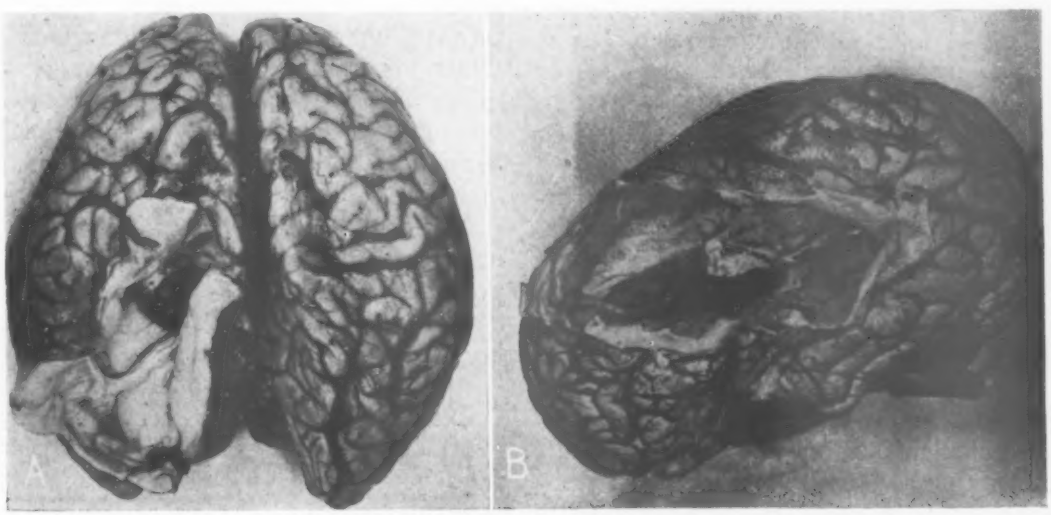


Fig. 26, *A* and *B*. Brain specimens of porencephaly. (*A*) porencephaly of left occipitoparietal region. (*B*) porencephaly in the left frontoparietal region.

weakness of the right extremities, with hyperactivity of the reflexes greater on the right. Plain roentgenograms of the skull revealed a calcified pineal body displaced to the right, downward, and backward. A preoperative ventriculogram revealed what was believed to be a large cystic glioma in the left frontal region. In the anterolateral portion of the air-filled cyst, a soft tissue mass with a rather smooth border was noted. The lateral and third ventricles were displaced to the right (Fig. 24 and 25).

A left frontoparietal craniotomy revealed the frontal dura to be discolored and hemorrhagic in appearance. Upon exposure of the cortex, a cyst was revealed in the anterior half of the frontal lobe. Several small cysts filled with fluid were noted in the large air-filled cyst which communicated with the ventricle. The cap of the cyst and the smaller cysts were removed and the communication with the ventricle was enlarged. Part of the cyst wall was removed for pathological study. No tumor tissue was seen at any point along the entire wall of the cyst.

Pathological Report of Specimen. "The specimen consists of four pieces of brain tissue covered with arachnoid on the surface and a smooth, slightly brownish layer through which fine blood vessels run on the inside. The thickness of the brain substance is 2 to 4 mm. The impression is that this is a cyst formation containing about 3 cc. of slightly bloody fluid. The brown surface of the cyst wall suggests the deposit of blood pigment."

Microscopic Description. "This is a piece of white matter covered with spendyma. The subspendymal layer is unusually thick. Hemosiderin is deposited here. The tissue towards the cortex contains nerve cells; however, without any definite architecture. Diagnosis: Porencephalic cyst."

Comment. Love and Groff[12] have reported a case of porencephaly with papilledema markedly improved by operation. It is generally believed, however, that the increased intracranial pressure with papilledema and erosion of the dorsum sellae noted in Cases II and III is not encountered in porencephaly. This case illustrates the difficulty one may experience in differentiating a communicating lobar porencephaly with mural cysts (Fig. 24) from a cystic glioma with a mural nubbin (Fig. 27).

FIG. 27. Cystic glioma in the right parieto-occipital region of a sixteen year old girl. The nubbin of the glioma in this instance is similar in appearance to that produced by a daughter cyst in the porencephaly (Fig. 24, *B*).

SUMMARY

We have reviewed a series of 29 cases of porencephaly. The etiologic factors, the symptomatology, and the location of the various lesions have been briefly discussed.

Unilateral change in the thickness of the skull was the most common observation in the conventional roentgenograms of patients with porencephaly. Generalized or localized thinning was most frequently present, and unilateral thickening of the vault was less often demonstrable. Asymmetry of the vault was also occasionally observed. Calcification similar to that in malignant gliomas was found in one instance.

Encephalography or ventriculography is necessary to establish the diagnosis of porencephaly.

The various types of porencephaly have been described and classified as "lobe," "interlobe," and "hemisphere."

Cortical or subcortical atrophy, enlargement of the ventricles, and arachnoiditis were found in association with porencephaly and may be contralateral, homolateral, or bilateral, and localized or generalized. There was usually a slight shift

of the ventricles and midline structures more often to the same side but frequently to the opposite and occasionally quite marked.

Porencephaly must always be considered in the differential diagnosis of mass, cystic and contracting lesions involving the brain. Cases were presented which clinically and roentgenologically could not be distinguished from mass lesions.

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PNEUMATOSIS INTESTINALIS

ITS ROENTGENOLOGIC DIAGNOSIS*

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and
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PNEUMATOSIS is defined as the presence of gas in an abnormal location in the body. When gas gathers into cyst-like accumulations within the wall of the intestine, the condition is known as "pneumatosis cystoides intestinalis." The diffuse spread of the gas into the intestinal tissues is labeled as "intestinal emphysema." These entities have been reported in the literature under such descriptive titles as "gas cysts of the intestine," "emphysema intestinorum," "diffuse emphysema of the intestinal wall," "multiple cysts of the intestine," and "emphysema of the cecum."

HISTORY

In 1876, Bang[1] published the initial description of pneumatosis intestinalis. In the most recent review of the subject, Jackson,[2] in 1940, accumulated all the purported cases available in the literature and added a case of his own, bringing the total to 172. Of these, 12 occurred in children and 160 in adults. The subject has been rarely reported in the American literature.

ETIOLOGY

Three major hypotheses have been propounded to explain the mechanism of the production of pneumatosis intestinalis.

(1) *Neoplastic.* This theory assumes the existence of a specific type of cell capable of secreting gas. The lack of satisfactory histopathological substantiation obviates acceptance of this presumption.

(2) *Bacterial.* This postulate presumes that bacterial action produces the gas in the interstitial tissues of the bowel wall. The majority of bacteriological studies in the reported cases failed to reveal the presence of bacteria. The clinical picture of the cases reported was unlike that which would be expected with a gas-forming infection. Furthermore, chemical analysis of the gas collected from the cyst-like areas has demonstrated the presence of oxygen, a finding which is not associated with bacterial lesions.

(3) *Mechanical.* This hypothesis presupposes a break in the integrity of the mucosa due either to over-distention of the intestine by gas or localized infection of the mucous membrane. With an increase in intraluminal pressure (i.e. hyperperistalsis or obstruction) gas is forced through the mucosal defect into the intestinal wall and tends to accumulate beneath the serosa. When the dissecting gas reaches the retroperitoneal region, it may spread rapidly over extensive areas, the extent and direction of spread being governed by the peritoneal planes and attachments. It should be emphasized that the gas is never intraperitoneal or "free" unless a break in the peritoneum itself occurs.

This hypothesis has the strongest evidence in its support. The majority of the reported cases are found in association with ulcerative diseases of the gastrointestinal tract, which present concomitant elements of obstruction and hyperperistalsis. Nitch and Shattock,[3] in analyzing 85 cases, reported that approximately 55 per cent occurred in patients with peptic ulcer and that 83 per cent were associated with varying degrees of intestinal obstruction.

CLINICAL FINDINGS

The clinical findings in cases of pneumatosis intestinalis vary with the extent

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and location of the gas. By itself this entity may be asymptomatic. However, as the gas accumulates, it may produce invagination of the mucosal and muscular coats of the bowel wall. With progressive accumulation of the gas, sufficient reduction of the lumen may occur to produce partial or even complete obstruction.

The major portion of the symptomatology is due to the complications attending pneumatosis. The primary pathology such as ulcer with stenosis or rupture, gastritis, etc., often overshadows the symptoms due to the pneumatosis so that it is not recognized. Physical examination may reveal a distended loop of bowel which simulates a tumor. The "tumor" is tender, has a spongy feel and is freely movable. It varies in size and consistency from day to day. Crepitation may be noted.

The variegated findings have led to such diagnoses as appendicitis, appendiceal abscess, malignancy and acute or chronic obstruction.

PATHOLOGY

The gross pathology is dependent upon the site and degree of the gaseous infiltration. The majority of cases have been localized to the ileocecal region. When associated with pyloric stenosis, the jejunum, omentum, and gastrohepatic ligament have been involved. The extent of the pathology varies from minimal accumulations of gas which are localized into discrete cyst-like formations to the extreme stage manifested by a sausage-like enlargement of the intestine due to diffuse emphysema. The cysts may grossly resemble hydatid cysts, but upon puncture, gas rather than fluid escapes. Characteristically, pressure upon the individual loculations of gas causes them to change their shape and position.

Microscopically, the blebs have no content other than gas except for occasional instances where they have been reported as containing small amounts of serum-like material. The cysts may show no obvious epithelial or endothelial lining but at times give the impression of being lined with serosa-like cells. They may resemble lymph spaces and this finding has been the basis for the theory that the gas is disseminated from the bowel lumen along the lymphatic channels. Varying degrees of inflammatory changes in the vicinity of the gas may be found. Hemorrhage, edema, granulocyte infiltration and giant cells have been reported but no characteristic pathological picture has been established. A distinction has been drawn as to the location of the gas spaces in children as compared to adults. In children, the gas is found predominantly in the mucosa and submucosa while in adults the gas accumulates in the subserosal plane.

ROENTGENOLOGIC DIAGNOSIS

Although the roentgenologic features of pneumatosis intestinalis has been noted in the European literature, no complete description has been given in the American reports. Lindsay, Rice and Selinger[4] stated, "Postmortem examination and operative intervention have been necessary for the recognition of this lesion; the diagnosis has never been made prior to one or the other of these two procedures." Pneumatosis intestinalis is undoubtedly fairly common but is overlooked due to the focusing of the physician's attention upon the basic pathology.

The roentgen findings consist primarily of the presence of translucent areas (gas) lying within the contour of the normal bowel. When a contrast medium such as barium is used, there is an inability to completely fill out the lumen of the bowel, giving the impression of filling defects. These, however, are inconstant and have a decreased density rather than an increased density such as is seen with tumor. The areas of decreased density lie between the contrast medium and the outer limits of the intestinal wall. They represent the accumulations of gas beneath the serosa which, forcing the mucous membrane and muscularis inward, produce the filling defects. The presence of inconstant filling defects of increased translucency is pathognomonic.

When the gas escapes from the limitation imposed by the serosa, its configuration in

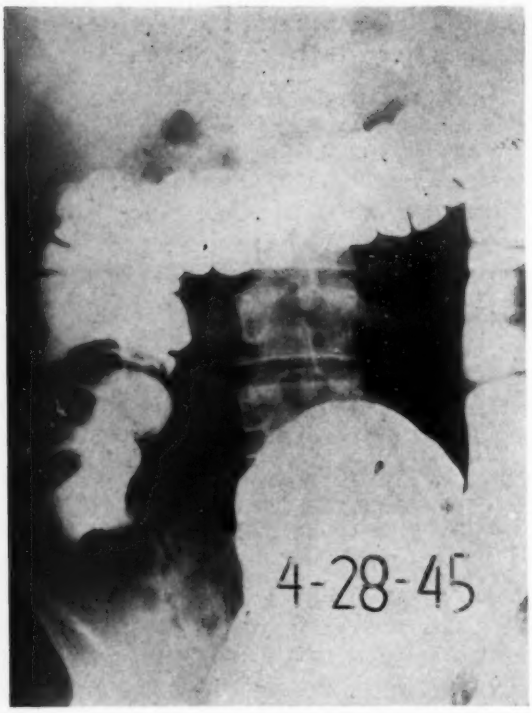

Fig. 1. Arrow points to translucent polypoid filling defects present in the cecum and ascending colon. These were originally thought to be due to tumor formation in the cecum. The remainder of the colon is entirely normal.

the retroperitoneal space is determined by the resistance of the tissues with which it comes in contact. The extent and rapidity with which it disseminates depends upon the maintenance of the increased intraluminal pressure, the persistence of the mucosal defect, and the rate of absorption. The gas may pass out between the layers of the mesentery, dissecting posteriorly and upward, coming to lie under the diaphragm and thus simulating free air in the abdomen. Lateral decubitus roentgenograms show that the air is not free. Extension into the mediastinum along the great vessels with the production of mediastinal emphysema is possible.

TREATMENT

The earlier literature is replete with case reports in which, because of the severity of the clinical findings, the patients were operated upon and the involved bowel often resected. In some instances, the blebs were merely evacuated. Recently it has been suggested that pneumatosis of itself is a benign process and should be treated as such. Reports have shown that the blebs may be absorbed in as short a time as three months.

The essence of the present status is that surgical intervention is determined by the primary pathology rather than the pneumatosis. If obstruction is present and observation shows a failure of resolution, interference is warranted. The absence of septic complications with pneumatosis is unusual and is worthy of note.

CASE REPORT

The patient was an Italian, male, aged twenty-two. He was first admitted to the hospital on April 17, 1945. His chief complaint was pain in right lower quadrant of five days' duration. The pain had first occurred five days previous to entry, appearing at night while resting. There had been mild burning in the epigastrium upon arising in the morning. There were no bowel disturbances, nausea or vomiting. Past history was irrelevant except for an appendectomy three years prior to admission. On physical examination, the only positive finding was an old scar in the right lower quadrant.

Laboratory Findings. Red blood count, white blood count, sedimentation rate, urinalysis and repeated stool cultures were negative. Stool examination for occult blood was positive until the patient was put on a meat-free diet when it became negative.

Course. The patient was afebrile during his first admission. Medication consisted of tincture of belladonna and elixir of phenobarbital daily. Bile salts were administered on April 19, 20, 21 and 22. Diarrhea appeared on April 23 and was treated with paregoric and bismuth.

Roentgen Examination. Examination on April 28, 1945, following barium enema (Fig. 1) was reported as showing multiple, translucent, polypoid defects in the region of the cecum and proximal half of the ascending colon. A roentgenogram of the chest on April 29 was reported as normal.

Subsequent Course. On May 2 the patient began to vomit frequently and was unable to retain any food.

On the basis of these findings, the patient was transferred to this hospital with a diagnosis of

intestinal obstruction due to tumor in the cecal region.

Transfer Admission, May 5, 1945. At the time of the transfer admission, the patient complained of pain in the right lower quadrant associated with nausea and vomiting. The pain was continuous, localized to the right lower abdomen and was associated with irregular abdominal cramps and distention. At this time the patient stated that for the past two years he had had frequent episodes of abdominal pain which were not related to the intake of food and not relieved by the taking of soda.

Physical examination at this time revealed a palpable mass in the right lower quadrant which was freely movable and soft.

Complete laboratory studies were normal. Temperature, pulse and respiration were normal.

Roentgen Examination. A survey roentgenogram of the abdomen was made on May 7, 1945 (Fig. 2). There is an unusual distribution of gas throughout the entire colon clearly outlining the haustral markings. There is, in addition, an accumulation of gas outside of the bowel lumen, lying in and adjacent to the bowel wall. This gas is not free in the abdomen.

FIG. 2. Flat roentgenogram of the abdomen. Note double effect of gas pattern from cecum to splenic flexure. Medial set of arrows points to contour of colon with outlining of haustral markings by gas. The lateral set of arrows points to the gas around the bowel and in the retroperitoneal spaces.

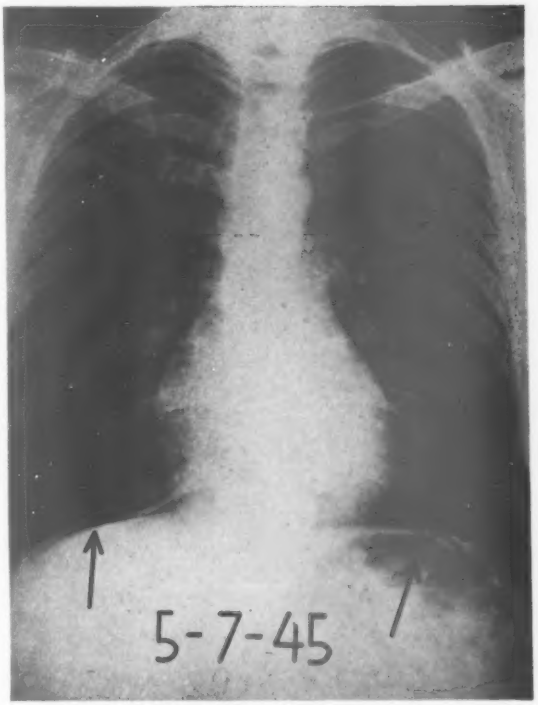

FIG. 3. The arrow beneath the right leaf of the diaphragm points to the gas present between the peritoneal and muscular layers of the right leaf of the diaphragm. The arrow above the left diaphragm points to the thin line of gas in the region of the left leaf of the diaphragm.

In light of the roentgenograms taken at this patient's first examination plus those at this examination, the diagnosis of pneumatosis cystoides intestinalis was made.

The roentgenogram of the chest (Fig. 3) revealed the following: There is a small accumulation of gas beneath the right leaf of the diaphragm. There is a thin line of decreased density beneath the left leaf of the diaphragm, which probably represents gas. These accumulations of gas apparently lie between the muscular and peritoneal layers of the diaphragm.

Roentgenograms on May 8 following a barium enema (Fig. 4 and 5) showed that the column of barium passes without obstruction or delay from the rectum to the splenic flexure. At this point the haustral markings become very prominent simulating spasm with partial occlusion of the lumen. There is mild hyperactivity of the colon. There are multiple translucent filling defects throughout the ascending

Fig. 4. The arrow in the right upper quadrant points to the dissecting gas in the region of the liver. The other arrows point to gas accumulated in the bowel wall. Note the extension of the gas from the cecum to the splenic flexure as compared to Figure 2 where it was localized to the cecum and ascending colon.

and transverse colon. These can be manipulated under the roentgenoscope so that they change slightly in shape and position. On the flat roentgenogram they are found to be due to accumulations of gas, some of which has escaped into the retroperitoneal tissues.

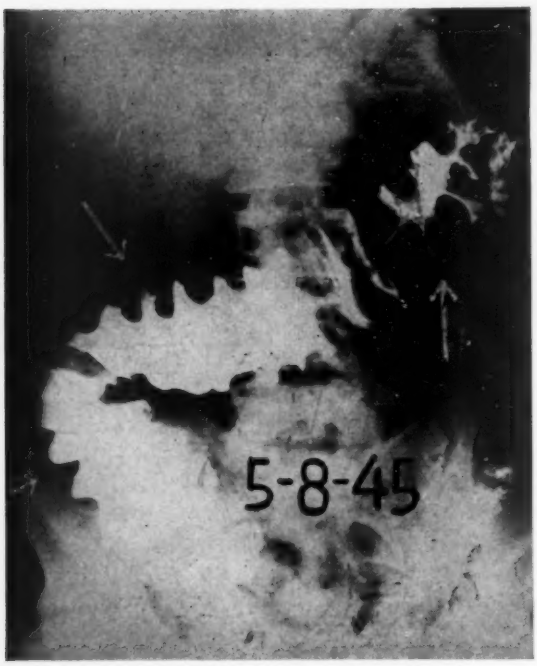

Fig. 5. Barium enema, emptying film. Arrows point to the gas in the wall of the colon and in the retroperitoneal planes. Note the appearance of spasm due to encroachment of the lumen by the accumulation of gas. There was no spasm present during the roentgenoscopic examination at this time.

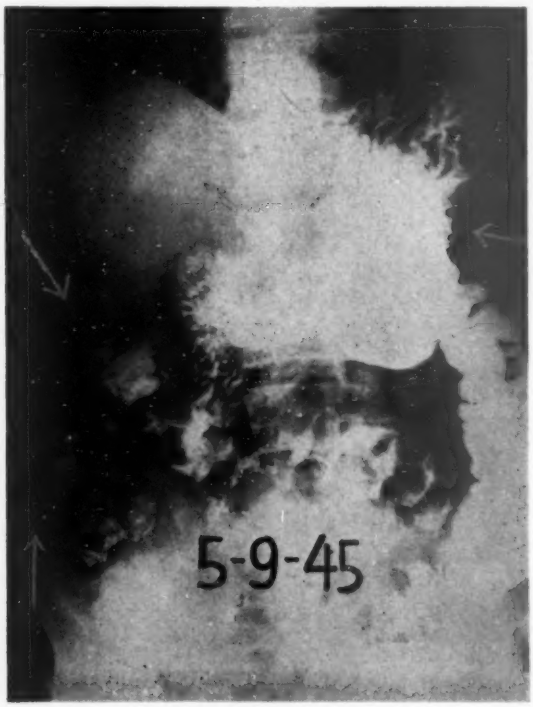

Fig. 6. Upper gastrointestinal series. The arrow in the left upper quadrant points to the gas in the retroperitoneal spaces behind the stomach. The gas is also still present in and about the right half of the colon.

A gastrointestinal examination on May 9, 1945 (Fig. 6) showed the following: The stomach and small bowel are apparently normal. On the roentgenograms there still can be seen a considerable amount of gas in the region of the ascending and transverse colon. Some of the gas is in the wall of the bowel, encroaching on the lumen and some lies outside of the limits of the bowel wall. There is a small amount of gas present in the retroperitoneal tissues behind and lateral to the stomach extending upward to the region of the diaphragm.

FIG. 7. The gas is no longer present in the region of either leaf of the diaphragm.

FIG. 8. The entire colon has now returned to normal. The haustral markings should be compared to those seen in Figures 4 and 5. There is a suggestion of a small amount of gas still present in the region of the hepatic flexure.

On a roentgenogram of the chest made on May 17 (Fig. 7) the previously noted gas between the layers of the diaphragm is no longer visualized.

In the examination on May 18 following a barium enema (Fig. 8) the column of barium passes from the rectum to the cecum without obstruction or delay. The contour of the bowel is normal and there is no gas visualized in or about the colon. The prominent haustral markings which were noted on the first barium enema are now shown to be artifacts. They were due to the invagination of the mucosa produced by the accumulations of gas beneath the serosa. Gas is no longer visualized in the retroperitoneal spaces in the region of the colon, stomach or diaphragm.

During the patient's stay in the hospital, the pain and the mass in the right lower quadrant disappeared. The patient appeared to make a complete recovery and was discharged on May 26, 1945.

SUMMARY

A case of pneumatosis intestinalis with extension of the gas into the retroperitoneal spaces and into the layers of the diaphragm is reported. No definite etiologic factor was established. It is possible that the use of cathartics in this patient was responsible for the extensive dissection of the gas during the period of observation.

The symptoms of intestinal obstruction which were manifested in this patient gradually subsided so that surgical intervention was unnecessary.

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SECONDARY MYELOFIBROSIS WITH PROGRESSIVE GENERALIZED OSSEOUS EBURNATION*

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APART from primary myelofibrosis, fairly widespread fibrosis of the bone marrow may occur in association with a number of diseases. Rosenthal and Erf[20] mention atypical Paget's disease, myeloma, neoplastic osteal processes, bone metastasis from carcinoma of the prostate, septicemia, benzene and radiation poisoning. To this list of secondary bone marrow fibrosis may be added hyperparathyroidism, the various granulomatoses and "spent" polycythemia. In addition to the distinctive individual features, the lesion may in one phase or another show the common histopathologic feature of fibrous replacement of bone. However, the majority of the patients afflicted with the above-mentioned disorders do not present the clinical picture of myelofibrosis. It is only exceptionally that one meets in the above disease entities the classical syndrome of secondary myelofibrosis.

Clinical myelofibrosis has two prerequisite elements. The first is destruction of a substantial portion of the blood-forming bone marrow and its replacement by a connective tissue derivative, usually fibrous tissue. The second necessary element is an attempt at compensatory hyperplasia by the remaining hemopoietic tissue, inclusive of the extramedullary potential hemopoietic organs. The spleen undergoes metaplasia and resumes its bloodforming function. Less frequently and to a lesser degree the liver shows similar metaplasia. Weakness, bone pains, splenomegaly and refractory anemia—the salient manifestations of myelofibrosis—are directly predicated upon these two basic processes of bone marrow replacement and the recruitment of all available resources for the production of blood constituents. The latter process of hyperplasia and metaplasia expresses itself in varying hemograms. The compensatory attempt may go on to produce a myeloid leukemoid reaction. The more common hemogram consists of a normo- or microcytic anemia with polychromatophilia, anisocytosis, a varying number of erythroblasts and some immature cells of the myelocytic series.

Both primary and secondary myelofibrosis may occur with or without osseous changes. According to Rosenthal and Erf about 50 per cent of the patients with myelofibrosis show on roentgen examination mottled rarefactions or irregular condensations in the cortical portions of the bones and splintering or elevations of the periosteum. Diffuse osteosclerosis is found in only a small percentage of myelofibrosis cases.

The occurrence of myelofibrosis and diffuse osteosclerosis secondary to widespread bone metastases from prostatic carcinoma has been reported twice in the English literature. Weber[27] in 1929 first reported such a case under the title of "Osteosclerotic Anaemia or Leukaemia." Later upon review of the microscopic slides the correct diagnosis of diffuse osseous metastatic carcinoma from the prostate was established. The patient was a fifty-six year old man whose course lasted one year. The symptomatology consisted of weakness, anemia, tenderness and pain in bones, occasional epistaxis and hypochlorhydria. During life, by rectal examination the prostate had been noted to be hard but small. At autopsy to the naked eye the prostate had not appeared abnormal. The author included illustrative roentgenograms of generalized condensation of the pelvis and upper femora.

* From the Tumor Service, Veterans Administration Hospital, Washington, D. C. Published with the permission of the Medical Director of the Veterans Administration, who assumes no responsibility for the opinions expressed or conclusions drawn by the authors.

In 1931 O'Crowley, Trubek and Goldstein[17] reported the second case. A forty-nine year old man whose first complaint was pain in the lower extremities and hips three months before his death. Rectal examination had failed to disclose a large prostate. Roentgenograms revealed diffuse osteosclerosis of homogeneous distribution involving all the bones examined. The article contains illustrations of the ribs, pelvis and lumbar spine.

In 1938 Swenson and Holzman[24] described a case which may belong to this group. Their patient was a thirty-six year old man who presented himself with the symptoms of weakness, anorexia, pallor, and pain in the back of one month's duration. Roentgenograms of the spine at that time showed slight decalcification with a peculiar ground-glass appearance. Terminally, one year later, the roentgenograms of the spine and pelvis revealed a diffuse homogeneous increase in density. Postmortem examination disclosed the condition to be the result of an unusual osteoblastic skeletal reaction to widespread carcinomatous metastases from an undetermined primary site. All organs examined including the stomach and one-half of the prostate were negative. The other half of the prostate was left in the body unexamined. The authors mentioned the possibility that their case belonged to the group described by Jarcho,[15] in which metatases usually from a primary scirrhous carcinoma of the stomach in a young adult spreading via lymphatics, were associated with thrombocytopenic purpura and anemia. Jarcho did not mention the roentgenographic skeletal findings in these cases.

In the non-English literature Putti and Faldini[19] reported a case which roentgenographically closely resembled ours. The case of Vignoles and Imhoff,[26] and the last 2 cases of del Solar, Diaz and Ovalle[7] probably also belong to this group.

The following report represents an additional case characterized by secondary myelofibrosis with progressive generalized osseous eburnation.

REPORT OF CASE

E. V., male, aged fifty-five, was admitted on February 26, 1945 to the Mt. Alto Veterans Hospital.

Chief Complaints. Pain in all joints; failing vision and pain in the left eye; bloody urinary discharge.

Family History. Mother died at ninety-two of "old age." Father died at seventy-two of a "spine condition." Wife and two children are living and well. Two children died in infancy.

Past History. In 1930 he had a submucous nasal resection. Since then there has been plugging of the nasal chambers with occasional extrusion of bloody clumps. In 1933 while pruning a tree the patient sustained an injury to his left eye with temporary blindness. This resulted in defective vision in his left eye. In 1936 a diagnosis of undulant fever was made. Ever since he has had bouts of fever several times a year, especially in the spring. His occupation has been that of a farmer, which included the care of sheep. On occasions he handled the usual insecticide sprays and powders. During his Army service he was stationed (1912–1917) in the Philippines, China and Japan. Venereal diseases are denied by name and symptoms. For at least twenty-five years the patient was in the habit of consuming excessive amounts of water. He would drink four to five glasses of water with each meal and additional quantities in between. The urinary output was correspondingly large.

Present Illness. In September, 1943, the patient first noted slowness of his urinary stream. Soon thereafter pain and swelling of all his joints set in, associated with progressive weakness and anemia. He was then sounded and a stricture of the urethra was found. Reference to records at another hospital revealed that the prostate was moderately enlarged with some hard areas in it. With the possibility of a prostatic malignancy in mind, his physician placed the patient on stilbestrol therapy. The marked secondary anemia was treated with whole blood transfusions—thirteen in all between May, 1944, and February, 1945. At another institution irradiation was administered in a vain attempt to alleviate the bone pains. During June, July and August, 1944, he received 2,175 r to the posterior lumbar region, 1,500 r to the lateral aspect of the right hip, 900 r to the anterior left hip, 1,050 r to the lateral left hip, and 600 r to the anterior right shoulder. The exposure

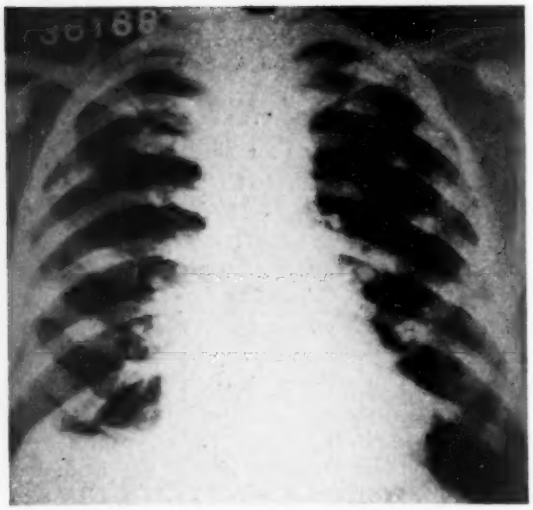

Fig. 1. Roentgenogram of the chest shows diffuse condensation of the clavicles and all the ribs. Their cortical margins cannot be clearly distinguished inasmuch as they merge with the general density of the marrow cavity. The axillary segment of the right sixth rib was resected for biopsy.

factors were 200 kv., 50 cm. distance, 15 by 20 cm. fields, Thoraeus filter.

The joint pains, the frequency and the nocturia continued. Occasionally he would pass frank blood in his initial stream, "coming from the penis" according to the patient. In January, 1945, additional symptoms manifested themselves. The patient began to experience left-sided frontal headaches, left periorbital

Fig. 2. *A*, lateral views of both legs taken on May 15, 1944, show normal bony architecture and density. (This roentgenogram was courteously supplied by Dr. H. Tuttle Stull, roentgenologist to the Suburban and Arlington Hospitals.) *B*, anteroposterior view of right leg and lateral view of the left leg roentgenographed March 17, 1945; the latter was taken with somewhat greater penetration. The tibiae reveal widening and thickening of the cortical portions with encroachment upon the marrow cavity. Note that the general contour of the tibiae has not been disturbed. The predilection of the metastatic eburnation to begin and attain maximum density at the extremities of the long bones is well illustrated in these roentgenograms.

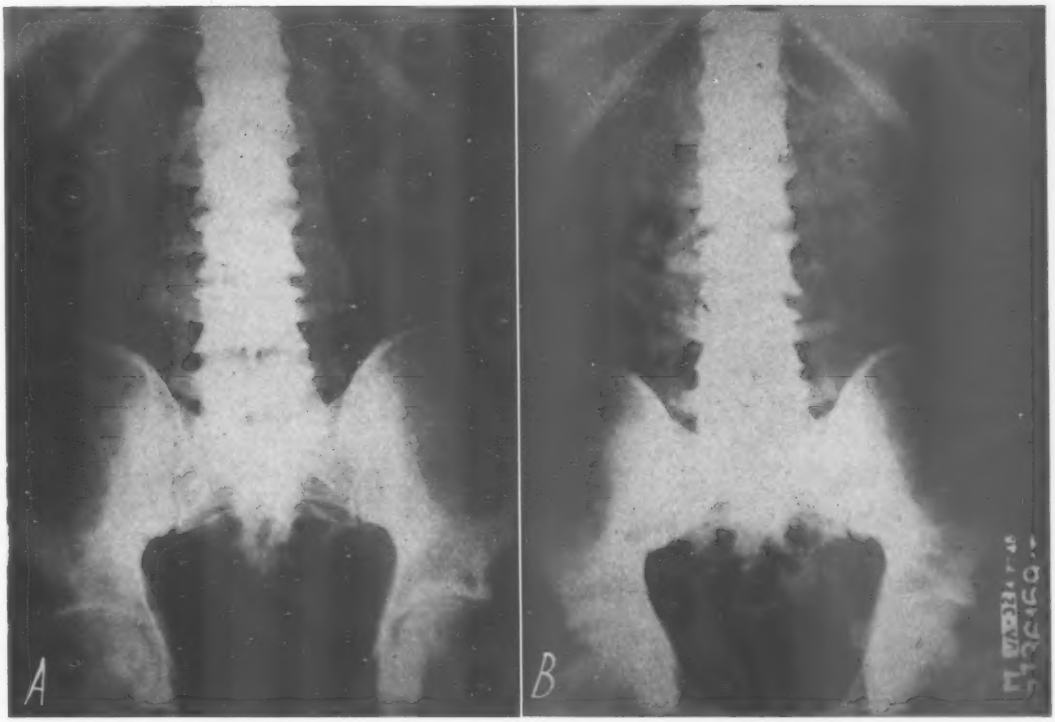

Fig. 3. *A*, lumbar spine and pelvis taken May 12, 1944, disclose diffuse condensation. (Courtesy of Dr. H. Tuttle Stull, roentgenologist to the Suburban and Arlington Hospitals.) *B*, lumbar spine and pelvis taken on April 27, 1945, reveal the maximum degree of eburnation to have been attained by the lumbar vertebrae. The sacrum and the innominate bones also increased in density during the interval.

numbness, blurring of the left lower visual field, and pain in his left eye with rapidly increasing blindness. He further noted almost complete suppression of saliva. Some diminution in the amount of saliva had been present for almost a year. Anorexia set in and he sustained a loss in weight amounting to 30 pounds in six months.

Physical Examination. Upon admission the patient was found to be an acutely and chronically ill man, bedridden and in very poor general condition. The skin was sallow. The left eye was practically blind—only finger perception; there was paresis of the left external rectus muscle. Heart and lungs were negative to percussion and auscultation. Blood pressure 120/60. Pulse 120, respiration 30, temperature 101° F. The spleen could not be felt. The wrists, knees, ankles, and especially the metatarsophalangeal, the metacarpophalangeal, and the proximal interphalangeal joints of the fingers were markedly tender, moderately swollen, and at times red. Clinically they were suggestive of rheumatoid arthritis. Pretibial edema one to two plus. The prostate was enlarged but not stony hard.

Laboratory Data. Blood count: hemoglobin 58 per cent; erythrocytes, 2,150,000; color index, 1.3; leukocytes, 5,200, with 62 per cent polymorphonuclears, 34 per cent lymphocytes, 2 per cent monocytes, and 2 per cent eosinophiles. Much variation in size, shape and staining qualities of the red blood cells. Sedimentation rate, 73 mm. in half hour. Blood Wassermann reaction, negative. Serum albumin 3.6, globulin 4.3. Nonprotein nitrogen 21.9, uric acid 4.2. Blood sugar 112. Agglutination for *B. tularense* and *Brucella abortus* were negative. Acid phosphatase 0.0 to 0.2 (normal 0.0 to 1.1); alkaline phosphatase 21.5 to 26.4 (normal 2 to 9). Gastric acidity: total 15, free HCl 0. Urine essentially negative, except for red blood cells when patient had urethral bleeding.

Roentgenograms showed diffuse condensation of the clavicles and all the ribs (Fig. 1). Their cortical margins could not be distinguished inasmuch as they merged with the general density of the marrow cavity. The skull

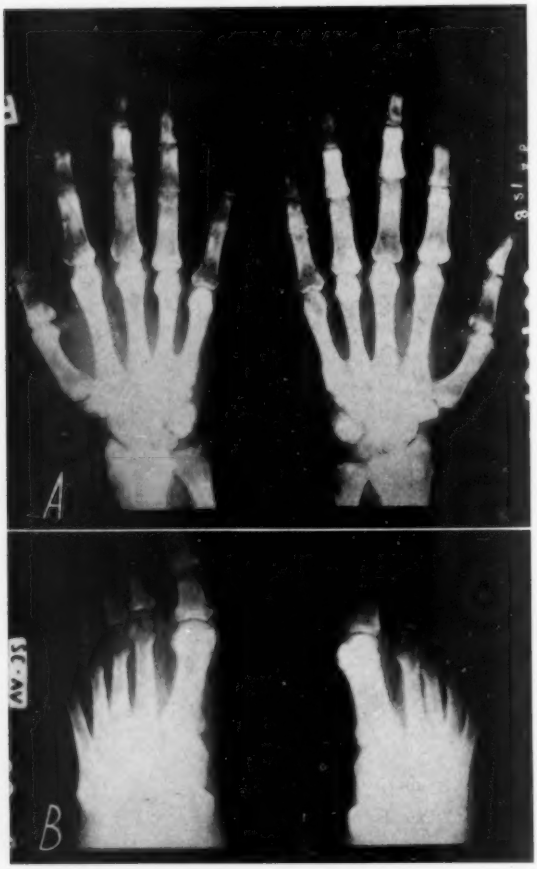

Fig. 4. *A*, roentgenograms of the wrists and hands in a case of secondary myelofibrosis with progressive generalized osseous eburnation due to metastases from a carcinoma of the prostate. The distal extremities of the radii, all the carpals, and the metacarpals show diffuse condensation. Patchy osteosclerosis is also seen in the phalanges. *B*, both feet present diffuse condensation of the metatarsals. The shaft of the right first metatarsal exhibits erosion of the cortex associated with a slight degree of periosteal reaction.

exhibited slight thickening of the diploe; the tables were within normal limits. There was a generalized increase in the density of the sphenoid bone, the mandible, the scapulae, ilia, and femora. The tibiae presented widening and thickening of the cortical portions with loss of distinctness and encroachment upon the marrow cavity. The general contour of the femora and tibiae was unaffected. Marked eburnation had taken place at the extremities of both femora and tibiae. The proximal as well as the distal extremities of the long bones (Fig. 2) exhibited this predilection for eburnation. In addition, the entire spine from the first cervical to the third sacral was of ivory consistency. The maximum degree of eburnation was attained by the lumbar vertebrae (Fig. 3). The distal extremities of the radii, all the carpals, the metacarpals, and the bases of the metatarsals showed diffuse increase in density (Fig. 4). Roentgenograms taken with greater penetration revealed more opaque patches scattered in the dense bones about the wrist joint. Mottled condensations were found in the talus and naviculae of each foot and all the phalanges of both hands. The shaft of the right first metatarsal presented erosion of the cortex with slight periosteal reaction. Similar periosteal reaction of slight degree was noted in the right first metacarpal.

Course. On the twelfth day after admission proptosis of the left eye was noted. The exophthalmometer gave readings of 17 mm. for the right and 22 mm. for the left eye. This was associated with chemosis and anesthesia of the left periorbital and temporal region. On March 26, 1945, the left orbit was explored. No pus or orbital tumor was found. The severe anemia required weekly transfusions. Subsequent blood counts showed some myelocytes and a few nucleated red blood cells and a color index which varied between 1.15 and 0.74.

On March 30 a 3 inch biopsy of the right sixth rib was taken. Grossly it showed an ivory-like cortex with a markedly increased resistance to sawing. The marrow cavity was completely obliterated by dense hard bone which could not be scraped out. On microscopic examination the bone trabeculae were found increased in width and in number (Fig. 5*A*). They exhibited a dense lamellar structure as seen in compact bone. The wavy linear condensations of calcium, in general following the contour of the lamellae, suggested concentric accretions of the trabeculae. The lacunae and the bone cells within them appeared normal. Multiple linear deposits of calcium were also found near the surface of many trabeculae. There were no lining osteoblastic cells, nor were osteoclasts to be found. The marrow spaces were relatively decreased in size. The bone marrow in general was almost completely replaced by a diffuse fibrosis, so that only a few marrow cells remained. In only a few areas were scattered infiltrating foci of highly anaplastic epithelial tumor consistent with the diagnosis of

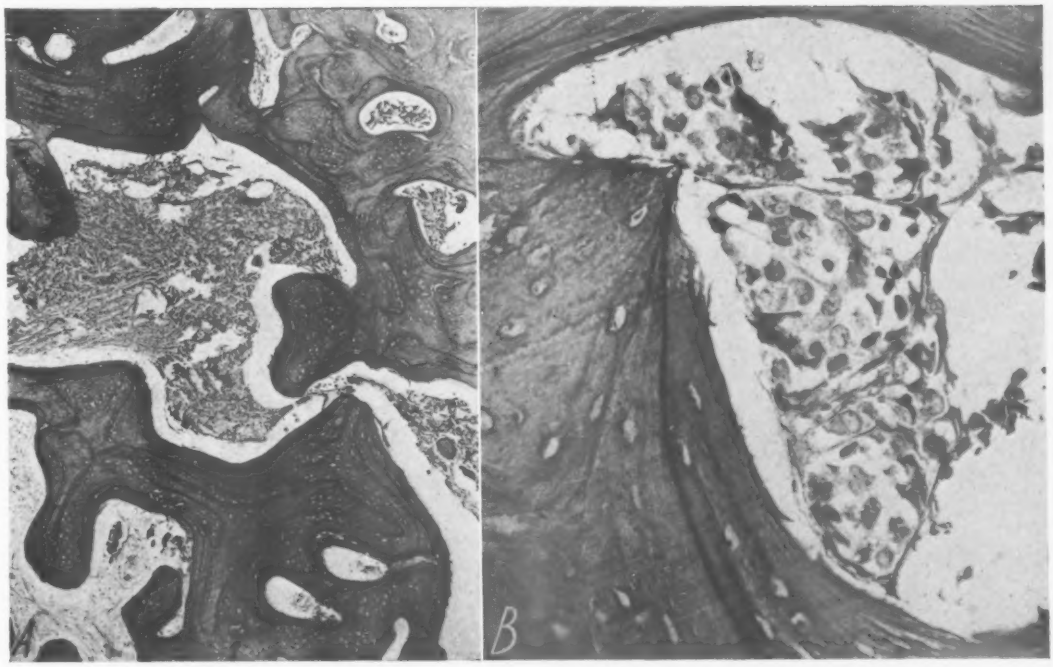

Fig. 5. *A*, rib biopsy. Photomicrograph (×75) (Army Medical Museum negative No. 89450). The bone trabeculae are increased in width and in number. They exhibit a dense lamellar structure. Note the wavy linear condensations of calcium, in general following the contour of the lamellae, suggesting concentric accretion of the trabeculae. There are no lining osteoblasts, nor osteoclasts. In the lower left hand corner can be seen the fibrous replacement of the bone marrow elements. In the center is a focus of infiltrating tumor cells. *B*, higher magnification (×450) photomicrograph. (Army Medical Museum negative No. 89449). Highly anaplastic metastasic epithelial tumor cells are seen in the marrow space, consistent with the diagnosis of a primary carcinoma of the prostate. The cells are polyhedral containing round vesicular nuclei showing a great deal of hyperchromatism. The cytoplasm of many of the cells appears foamy and vacuolated.

a primary carcinoma of the prostate (Fig. 5*B*). These metastatic foci consisted of polyhedral cells containing round vesicular nuclei showing a great deal of hyperchromatism. The cytoplasm of many of the cells appeared foamy and were vacuolated. The arrangement of the cells imparted the suggestion of alveolar formation.

Chemical analysis of the rib bone yielded: Ash, 63.14 per cent of the dried specimen (normal 58.80); calcium, 0.32 mg. per 1 mg. of bone ash (normal 0.22). The lead content was normal. No fluoride, arsenic or bismuth was found.

The patient ran an irregularly febrile course, ranging from 99 to 102° F. On April 5, 1945, he developed a left parotitis. The spleen became palpable on April 23. Rectal examination on April 27 disclosed an enlarged prostate of hard consistency. The patient had been off stilbestrol therapy for at least two months. The anemia was progressive despite continued weekly transfusions. The patient rapidly grew weaker and died on May 18, 1945. Permission for autopsy was refused.

COMMENT

From the roentgenologic viewpoint several diseases have to be considered in the differential diagnosis of diffuse bone condensation.

1. *Osteopetrosis.* This disease occurs in a much younger age group. The skull is usually involved and heavily so. Any area of bone under examination will show a continuous density of approximately the same degree except at the periphery of the involved area. A history of consanguinity may be obtainable.

2. *Melorheostosis.* The "flowing wax"

appearance is characteristic of this disease.

3. *Osteopoikilosis.* This developmental anomaly consists of numerous dense bone islands. The skull is spared. Phalen and Ghormley[18] reported a case having some of the features of osteopoikilosis, osteopetrosis and melorheostosis.

4. *Syphilis.* The sclerosing osteitis of lues is usually localized. It involves one, two or three bones. Francis and Kampmeier[8] described 117 bone lesions of all types, inclusive of luetic periostitis and gummatous osteomyelitis in 67 patients—an average of two lesions per patient.

5. *Lymphoblastoma.* In this group, too, the lesions are confined to several bones and most often only to parts of bone. Lymphosarcoma manifests itself almost entirely by osteolytic lesions. In Hodgkin's disease only 12 per cent are purely osteoblastic, found mostly in the lumbar vertebrae.[25] The average is less than four bones involved per patient. Craver and Copeland[6] reported bone changes in 6 out of 86 cases of lymphatic leukemia. These changes consisted of elevation of the periosteum due to infiltration beneath it. This was occasionally followed by osteosclerosis from proliferation of new bone. Extensive generalized osteoporosis may sometimes be present without localized areas of destruction. Snelling and Brown[23] reported bone changes in some stage of the disease in 8 out of 12 children. Their most consistent finding was a rarefied area near the end of the bone adjacent to the epiphyseal line together with elevation of the periosteum. Roentgenographic bone involvement in myelogeneous leukemia is extremely rare.

6. *Poisons.* The eburnation of the extremities of the femora, tibiae and radii suggested the possibility of phosphorus, lead, fluoride and radium poisoning. Chemical examination of the rib was negative. Holm[11] emphasizes the point that phosphorus osteosclerosis occurs only when a process of ossification is going on. It, therefore, is not seen to originate later in life after completion of skeletal growth. No radioactivity of the patient could be demonstrated. Radiation osteitis did not enter into consideration in this case. The bone lesions existed prior to irradiation and were found in regions not exposed to irradiation. Besides, in radiation osteitis there is usually a central or off-center osteolytic element.

7. *Paget's Disease.* This is the most likely entity with which metastatic carcinoma of the prostate may be confused. In its characteristic form Paget's disease presents areas of condensation alternating with irregular zones of rarefaction. The cortex of the long bones shows marked thickening and longitudinal fibrillation. The most distinguishing feature is the deformity of the outer bony contour. The rapid progression of the osteosclerosis (Fig. 2) is definitely against Paget's disease.

8. *Metastatic Carcinoma of the Prostate.* In the majority of cases both osteolytic and osteoblastic metastases occur. Huggins[13] found only 2 out of 31 to be purely osteolytic. In these 31 patients with advanced prostatic carcinoma he never encountered metastases distal to the knee or elbow joints. Geschickter and Maseritz[10] listed no foot or hand metastases in a series of 1,041 cases of carcinoma of the prostate, and only 1 involving the humerus, 1 the clavicle, 1 the tibia, 1 the scapula, and 2 the ribs. The 6 patients with advanced and widespread osseous metastases from carcinoma of the prostate recently seen by us failed to show any lesions below the knees and elbows. Lanari and Jorg[16] described a case of Paget's disease with condensation of the distal epiphyses of both femora and proximal and distal epiphyses of both tibiae. The involvement of the hands and feet in Paget's disease is equally rare. Brunner[3] mentioned only 1 case out of 26 patients with Paget's disease with metatarsal and phalangeal lesions. On the basis of the clinical findings, the rib biopsy and the roentgenographic manifestations, the patient constituting the subject of our report is presented as a case of myelofibrosis secondary to a carcinoma of the prostate with the unusual features of

metastatic osseous condensations in the limbs distal to the elbows and knees.

The mechanism of new bone formation in prostatic skeletal metastasis has as yet not been settled. Sharpe and McDonald[22] stated that the degree of malignancy had no bearing on the amount of new bone formation. The only correlation they could find was as to the amount of new connective tissue deposition. Putti and Faldini[19] found three types of bone changes: namely, fibrotic transformation of the medulla, areas of metaplastic ossification of the cartilage and areas of new bone formation. Brunschwig,[4] on the other hand, concluded that there was no evidence for metaplasia into osteoblasts and other mesoblastic elements within the marrow and in the soft parts immediately overlying the cortex. He favored the concept that new bone in intramedullary osteoblastic metastasis is the result of a combination of two factors varying in relative importance. These are: (*a*) infarction of the cortex and marrow resulting in endosteal stimulation due to reduced circulation. Infarction may also produce aseptic necrosis of bone and this is followed by creeping replacement of the dead bone by living bone; (*b*) direct stimulation of endosteal osteoblasts. This is in accord with Huggins' suggestion that prostatic epithelium also has "osteogenic" properties analogous to that of urinary bladder epithelium. No experimental proof for these "osteogenic" properties of prostatic epithelium has as yet been presented. No bone formed in the prostatic transplants as did in the bladder transplants. On the clinical side, Schmorl[21] described the only case of bone formation in soft tissue metastasis of carcinoma of the prostate. Ashburn[1] reported 1 case of carcinoma of the prostate with a nodule of bone in the prostate, 10 by 14 mm. intimately associated with tumor cells. Huggins[12] made no mention of the prostate in his list of heterotopic bone formation.

A third factor commonly quoted among the hypotheses of new bone formation is that of a "defense reaction" to a foreign body or noxious element. The presence of metastatic condensations in the hands and feet cannot be explained on Cave's[5] hypothesis that stimulation of the sympathetic fibers by adjacent involved lymph nodes causes vasoconstriction with consequent osteosclerosis. Even if this were true in the lumbar region no such anatomical correlation obtains in the hands or forearms. No enlarged lymph nodes could be demonstrated in the regions of the cervical sympathetic ganglia or along the course of the sympathetic fibers to the upper extremities. Similarly, because of anatomical considerations one cannot invoke Batson's[2] vertebral system of veins to account for the spread of metastases to the bones about the wrists and knees. Batson does not claim any connection between this vertebral system of veins and the veins of the extremities. The predilection of the bone condensation to begin at and attain the greatest density in the extremities of the long bones—the region best supplied with blood —suggests a blood stream spread. This is at variance with Geschickter's[9] opinion that spread via the lymphatics causes osteoplasia, via blood stream—osteoclasia. Besides, no lymphatic vessels have as yet been demonstrated in bone. Putti and Faldini,[19] after a careful gross and microscopic study, could not find any involvement of the muscles and soft tissues of the extremities and their lymphatics. Only in the immediate vicinity of the osseous cortex at the muscle insertion were several small neoplastic nodules discovered. These authors concluded that the neoplasm was first generalized through the lymphatics, thence through the blood stream it reached the skeleton, where it was detained by a biochemical or cellular affinity. The predilection of the metastases for the extremities of the long bones may be correlated to the distribution of red marrow in the adult. Willis[28] noted that "metastatic growths in bone are almost invariably situated in red bone marrow. In patients with cachectic anemia, especially that due to metastatic growth in bones, the distribu-

tion of red marrow may depart widely from the normal. Compensatory erythropoiesis results in the replacement of areas of yellow marrow by hyperplastic red marrow, and metastatic growth may then be found in these situations. Thus, although in healthy adults the middle and lower third of the humerus and femur and most of the bones of the distal segments of the limbs contain only fatty marrow, metastatic growths in these situations are found almost invariably to be situated in red marrow. The much greater vascularity of red bone marrow as compared with yellow marrow is at least partly responsible for the much greater frequency of metastases in the former, but it may also be that red marrow is an intrinsically better soil than yellow marrow for establishment of metastatic growth." The finding of metastatic bone condensations in the tibiae, radii, carpal, metacarpal, tarsal, and metatarsal bones in our patient are in consonance with the above-quoted concepts of Willis. The compensatory hemopoiesis attempting to combat the marked anemia of myelofibrosis most likely resulted in red marrow transformation and thus prepared the soil and the vascularity for the deposition of metastatic foci in the segments of the limbs distal to the elbows and the knees.

The high serum alkaline phosphatase in this case is in accordance with the active new bone formation. The normal limits of the acid phosphatase values prior to stilbestrol therapy may or may not be of significance. Huggins and Hodges[14] stated that no deduction could be made from the enzyme study of the serum with respect to the osteoblastic or osteolytic nature of the metastatic lesions. Out of 25 cases of carcinoma of the prostate with skeletal metastases they found 6 with a normal acid phosphatase.

SUMMARY

1. A case of secondary myelofibrosis with progressive generalized osseous eburnation due to skeletal prostatic carcinoma metastases is presented. Only two similar cases were described in the English literature.

2. The prognosis in such cases is worse than in the average carcinoma of the prostate. The course varies between one and one and one-half years.

3. The differential diagnosis of diffuse bone condensation includes osteopetrosis, melorheostosis, osteopoikilosis, syphilis, lymphoblastoma, poisons (lead, phosphorus, fluoride, radium), radiation osteitis, Paget's disease and metastatic carcinoma.

4. Clinical myelofibrosis has two prerequisite elements; namely, destruction of bone marrow and an attempt at compensation by the remaining hemopoietic tissue, inclusive of metaplasia in spleen and liver. The cardinal symptoms are weakness, bone pains, a varying degree of splenomegaly and a refractory anemia with nucleated red blood cells and immature white blood cells in the peripheral blood.

5. Histopathologically the involved bone shows an increase in width and number of the trabeculae with linear calcium deposition. The lamellae present normal lacunae and bone cells. A conspicuous feature is the scarcity or complete absence of lining osteoblasts and osteoclasts. This may be due to the fact that we are seeing the end-result in the already dense bone rather than the active phase of bone formation in the condensing bone. The marrow spaces contain fibrous tissue with sparsely scattered infiltrative foci of tumor cells.

6. This patient presented the additional unusual features of proptosis of the left eye, metastases to the bones of the hands and feet which symptomatically and objectively resembled rheumatoid arthritis, and in the limbs a predilection of the osteosclerosis to begin at and attain greatest density in the extremities of both humeri, radii, femora, and tibiae. The findings of metastatic osseous condensations in the bones below the elbows and knees may be predicated upon the prior transformation of the yellow into red marrow in the body's

attempt at compensatory hemopoiesis to combat the marked anemia of his myelofibrosis.

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THE ROENTGEN DIAGNOSIS OF VOLVULUS OF THE SIGMOID WITH INTESTINAL OBSTRUCTION*

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INTRODUCTION

VOLVULUS of the sigmoid is an important cause of intestinal obstruction. It is a condition in which early diagnosis and the immediate institution of proper therapeutic measures are essential if the life of the patient is to be saved. In the past, the mortality in obstruction due to volvulus of the sigmoid has been extremely high, averaging approximately 40 per cent. This elevated death rate has been due principally to three factors: (1) clinical diagnosis is extremely difficult and in many cases impossible; (2) cecostomy, intubation, and similar palliative procedures customarily resorted to in the treatment of patients suffering with intestinal obstruction are unavailing in volvulus, merely resulting in delay which serves to increase the mortality and (3) prompt relief of the obstruction is necessary to prevent strangulation with consequent necrosis of the bowel, hemorrhage and shock.

Roentgen studies offer a method which enables the observer to establish the site of the obstruction and in many instances the nature of the lesion. This topic is therefore of unusual interest to the roentgenologist. It is our purpose to review the clinical manifestations which should make the clinician suspect the possibility of volvulus of the sigmoid and to describe in detail the roentgen methods of investigation by which a diagnosis may be made.

DEFINITION

Volvulus is an abnormal rotation, torsion or twisting of the intestines, at times associated with knotting of the loops. The volvulus may be a rotation of the bowel on its own axis, torsion on its mesentery, or a combination of both. Rarely, there may be intertwining with another loop of intestine.

ETIOLOGY

While not a rare condition, the incidence of volvulus of the sigmoid is not great. Sweet, in a report comprising 53 patients with intestinal volvulus, found 36 cases involving the small intestines, 6 in the cecum, and 10 in the sigmoid. Griffin, Bartron and Meyer reviewed 458 cases of intestinal obstruction from the records of the Cook County Hospital (Chicago) and found that 37 were volvulus of the sigmoid. Statistics indicate that 2–4 per cent of all bowel obstructions are due to volvulus. However, reports from Russian and Serbian sources show a much higher proportion, from 23–34 per cent of patients suffering from obstruction having an associated volvulus. This greater incidence is apparently due to dietary habits, as these peoples eat more vegetables and similar bulky foods; also, they may go for long periods with very little food and then ingest relatively large amounts at one time. Volvulus may occur at any stage of life, and is more frequent in men than in women. It is often associated with megacolon.

PATHOGENESIS

Volvulus of the sigmoid is particularly likely to occur if the sigmoid is dilated, long and redundant. These changes may be congenital or the result of chronic constipation

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and bowel stasis, which predispose to lengthening and simultaneous increase in the caliber of the gut. Retention of fecal masses favors the development of volvulus, the weight of the feces causing the heavier loops to sag and slide over a portion of the bowel which is empty or only partially filled. An associated shortening or narrowing of the mesentery may cause sharp angulation, drawing the two limbs of the sigmoid closer together and causing a volvulus; this is most apt to occur if adhesions are present between the sigmoid loops. Pressure from large pelvic masses may, similarly, force the loops of sigmoid closer together. Increased peristaltic activity associated with dietary indiscretions or resulting from the use of strong cathartic or purgative drugs is also an important factor in the production of volvulus.

The volvulus may be 180°, 360°, or more, cases having been reported with three or four complete turns. The involvement may be limited to one area of the sigmoid; frequently, however, it is a double twist with shutting off of a segment of bowel of variable length between the two areas of torsion (Fig. 2*B*). The rotation is more often clockwise than the reverse. The tightness of the twist is of much greater importance than its degree or direction. Not all cases result in a permanent or complete obstruction and spontaneous detorsion is apparently a not infrequent occurrence. This is evidenced by the fact that many patients give histories extending over long periods of repeated attacks of pain and distention which disappeared with rest and therapy. However, these episodes are not entirely innocuous for they doubtless cause shortening of the mesentery and adhesions, important factors in the eventual production of a volvulus which is irreducible, as indicated above.

When complete obstruction supervenes, gas and fluid are rapidly accumulated proximal to the point of stenosis or in the occluded loop with resultant distention, which in some instances is very severe in degree. The distended loops may become many times normal size and rise out of the pelvis into the right upper quadrant or to fill the entire abdomen with upward displacement of the liver and diaphragm. Enlargement of the blood vessels produces hemorrhage into the colon causing loss of large amounts of blood and the resultant development of severe shock. Unless detorsion occurs or the obstruction is promptly relieved, strangulation ensues and necrosis may develop rapidly, within a few hours in some cases. Peritonitis is a frequent complication.

CLINICAL ASPECTS

Patients with volvulus may present a long antecedent history of constipation with repeated attacks of abdominal pain of varying severity in the past, which may properly be assumed to have been due to recurrent, mild torsions which had undergone spontaneous correction. In others, there have been no previous episodes. The acute attack is not infrequently preceded by dietary indiscretions, particularly the ingestion of large quantities of bulky foods or a purgative. The onset is usually sudden and dramatic, the severity varying with the degree of obstruction. Constipation is very marked, enemas producing little or no result. Diarrhea with blood and mucus may be present. There is no belching or flatus. Vomiting seldom occurs. The patient may go into collapse and shock. Cecostomy, intubation and similar palliative measures are unavailing. Transfusions and subpectoral fluid may produce temporary improvement, but the patient's condition usually grows rapidly worse despite all attempts at palliation.

In the early stages, the abdominal wall may be soft and the tense sigmoid loops palpable in the pelvis and abdomen. More commonly, there is marked distention of the entire abdomen and palpation is impossible. Tenderness may or may not be present; at times, it is noted in the very early stages of strangulation and later if peritonitis has developed. Percussion varies according to the contents of the involved

loops; when distended with gas, there is tympany; if filled with fluid, there is dullness. Rectal examination gives no information of value. Sigmoidoscopy may demonstrate the lesion if the volvulus is low in the sigmoid. However, the obstruction is usually too high to be seen with the sigmoidoscope and the patient's condition may be too critical to permit of accurate observation.

ROENTGEN FINDINGS

In the study of a case of suspected volvulus of the sigmoid, the roentgen examination is best begun with survey roentgenograms of the abdomen. These studies should be carried out in both the recumbent and erect positions if possible. If the patient is too ill to stand or sit, the lateral decubitus may give valuable additional data. In the typical case of volvulus with obstruction, there may be demonstrable markedly distended loops of sigmoid which rise out of the pelvis into the mid-abdomen, the right upper quadrant, or to occupy the entire abdomen to the level of the diaphragm. If the volvulus has resulted in the formation of a closed loop, fluid levels may be visualized; if these levels are double, the diagnosis of volvulus may be established with a fair degree of certainty. It may in some instances be possible to demonstrate two points of obstruction in gas filled loops of bowel.

However, in our experience survey roentgenograms of the abdomen serve only to indicate that obstruction is present and that it is most probably in the lower portion of the colon, without making it possible to determine definitely the exact site or nature of the lesion. If more precise data are to be obtained, it is necessary to resort to the use of the barium enema. In our clinic, this is used in all cases unless the condition of the patient is so grave that it appears contraindicated. The opaque fluid is administered slowly with gravity pressure only, the container being suspended 18–24 inches above the table, and under constant roentgenoscopic control. We feel that with these precautions carefully observed, the procedure is safe and provides invaluable data which are not obtainable in any other way and may be the means of saving the life of the patient. It must be constantly borne in mind that in some instances of volvulus, there is a valve type of obstruction which permits the enema fluid to enter relatively freely while expulsion cannot take place. Therefore, only small amounts are administered and the examination is terminated when the lesion has been demonstrated satisfactorily. If the volvulus has resulted in complete obstruction of the lumen of the colon, the opaque mixture will fill only the ampulla of the rectum and lower sigmoid. At this point, there will be observed a rounded or tapered point of stenosis which is smooth in outline and sharply defined. Not uncommonly, the obstruction to the barium enema is incomplete and small or moderate amounts of the injected fluid pass through the markedly narrowed points where the volvulus has occurred. Spiral bands of linear density alternating at irregular intervals with narrow bands of increased radiance over an area several centimeters in length in the sigmoid colon delineate the torsion of the colon. Spot roentgenograms with pressure under roentgenoscopic control usually demonstrate the corkscrew-like arrangement of the mucosa more satisfactorily than the routine roentgenograms. These findings are pathognomonic of volvulus and it is possible to establish a definite diagnosis on the basis of these changes. It is usually advisable to discontinue the examination at this point. However, the studies can be continued with caution and further filling of the colon may demonstrate the size of the involved loop, the presence of a second point of torsion in the proximal portion of the sigmoid, and the degree of rotation. These data may prove of value to the surgeon in planning the operative procedures to be used. After films have been exposed at various angles, the patient is permitted to expel as much as possible of the injected material and further observations are

made. These, also, should include roentgenoscopic studies, spot and routine roentgenograms with the Bucky diaphragm at various angles. The volvulus may in some instances be visualized more clearly at this time than when the colon was more completely filled with the opaque material (Fig. 2*B*). Double contrast studies may be helpful, but here particularly, caution is essential during the injection. We feel that this procedure is usually not necessary. Some observers have reported actually seeing the affected loops untwist during the roentgenoscopic studies, thus effecting a cure.

TREATMENT

Once the diagnosis of volvulus of the colon with obstruction is definitely established, surgery is indicated. Transfusion and other supportive measures are used as necessary prior to operation. The aim of the surgeon is to restore the normal position of the colon and correct or eliminate so far as possible any anomalies which might tend to result in recurrence. Resection and anastomosis, either in single or multiple stages, should be done if strangulation has occurred.

CASE REPORTS

Case 1. F. W., male, white, single, aged ninety-seven. Patient entered the hospital because of swelling of the abdomen of three days' duration. He had been well until four years ago, when he developed severe constipation, which required mineral oil daily for relief. Three days ago, because of abdominal distress, he took a strong laxative. This was followed by a constant dull, gnawing pain in the left lower quadrant and distention. He passed large amounts of gas rectally, but there was no bowel evacuation for two days. On the day of admission, there was a small, watery movement. He had no fever or chills and had not lost any weight. He had severe nausea, but no vomiting. On examination, the patient was obviously extremely ill. The abdomen was markedly distended, with eversion of the umbilicus. There was no fluid wave. Marked tympany was elicited on percussion. The rectal examination was negative. The lungs were clear. Heart sounds were poor and irregular. The white count was 13,950; hemoglobin

Fig. 1. Case 1. *Volvulus of the sigmoid.* Barium enema studies showed normal filling of the rectum. There was partial obstruction in the region of the lower portion of the sigmoid with no apparent irregularity of outline. The volvulus is indicated by the arrow. The dilated loop of sigmoid is partially filled with the opaque mixture and contains much gas.

80 per cent; Hinton test negative. The urine contained no albumin; specific gravity 1.025, sugar 4+. A clinical diagnosis of probable cancer of the colon was made.

Roentgen studies on the first hospital day revealed marked distention of the colon with gas. On barium enema examination, there was complete obstruction in the region of the lower sigmoid. A cecostomy was performed. The colon was markedly distended with gas, cyanotic and edematous. The patient's condition was so poor that exploration was deemed inadvisable. There was no improvement after this operation. Two days later, the opaque enema studies were repeated. The rectum was dilated and filled normally. In the lower portion of the sigmoid, the lumen was markedly narrowed; there was no irregularity of outline. Small amounts of the opaque mitxure passed through the area of stenosis and a volvulus of the sigmoid was dem-

Fig. 2. Case II. *Volvulus of the sigmoid with partial obstruction. A*, the torsion of the colon is visualized clearly (arrow). The sigmoid is markedly dilated. *B*, after evacuation of the opaque enema. The dilated sigmoid is still partially filled with the opaque mixture. The two points of narrowing associated with the volvulus are indicated by the arrows. The obstruction was of the valve type, the sigmoid and descending colon retaining practically all of the opaque material which had been injected. The importance of the post-evacuation roentgenogram is well illustrated, as the points of torsion and the distention of the sigmoid are better seen than in *A* made during filling of the colon.

Fig. 3. Case III. *Volvulus of the sigmoid with obstruction.* Roentgenogram of the abdomen showing a markedly distended loop of large bowel in the left side of the abdomen extending from slightly below the level of the iliac crest into the left upper quadrant.

onstrated. The examination was thereupon discontinued. Operation performed later in the day revealed torsion of the sigmoid with one complete turn at the site indicated roentgenologically. The sigmoid was necrotic and fecal matter was present in the left lower portion of the abdominal cavity. Mickulicz resection was performed. The patient died twenty-four hours later.

Case II. J. B., male, colored, married, aged sixty-six. The patient entered the hospital because of severe abdominal cramps and constipation; the symptoms had been present for three days. A compound cathartic pill taken the

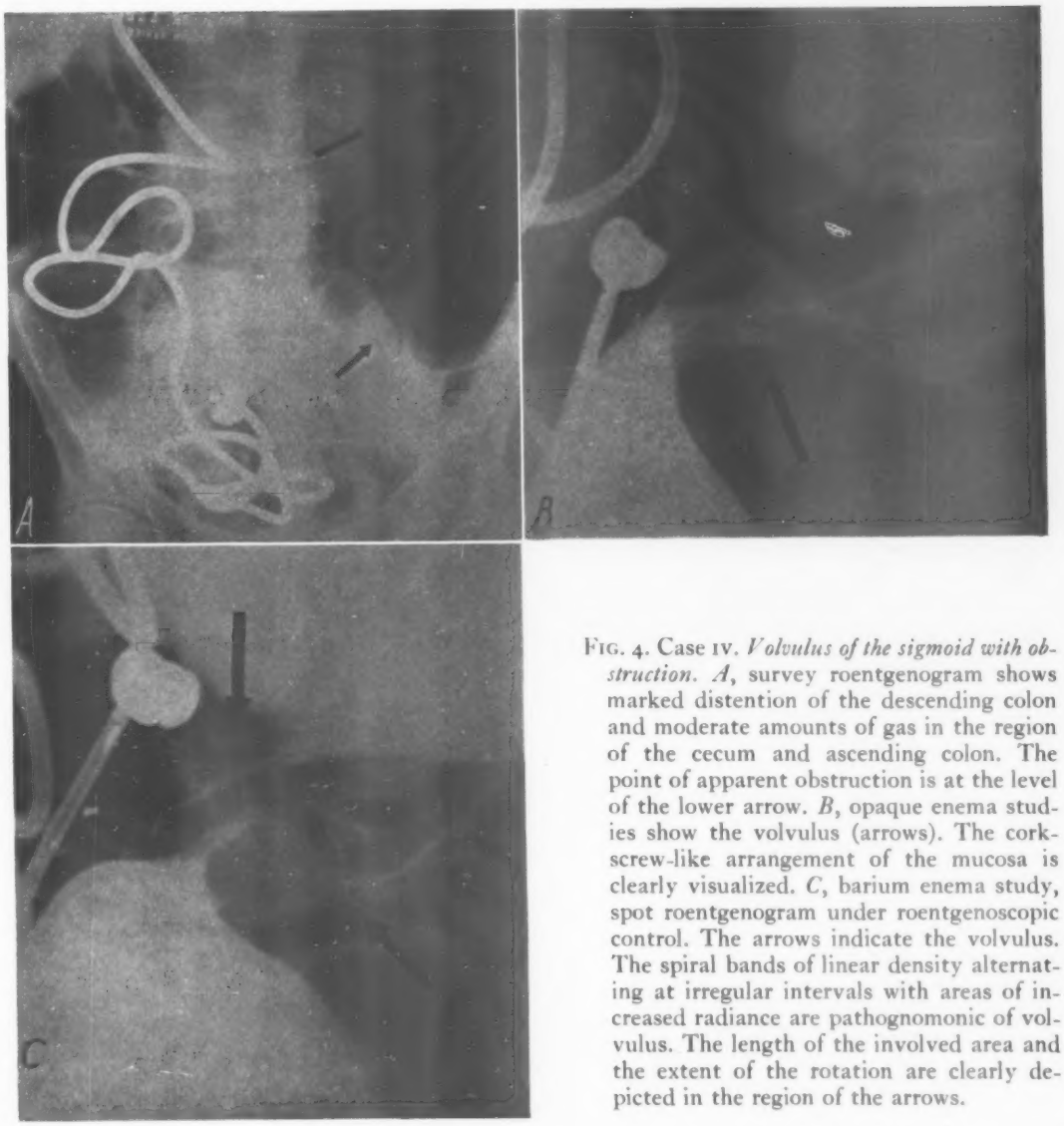

Fig. 4. Case iv. *Volvulus of the sigmoid with obstruction. A*, survey roentgenogram shows marked distention of the descending colon and moderate amounts of gas in the region of the cecum and ascending colon. The point of apparent obstruction is at the level of the lower arrow. *B*, opaque enema studies show the volvulus (arrows). The corkscrew-like arrangement of the mucosa is clearly visualized. *C*, barium enema study, spot roentgenogram under roentgenoscopic control. The arrows indicate the volvulus. The spiral bands of linear density alternating at irregular intervals with areas of increased radiance are pathognomonic of volvulus. The length of the involved area and the extent of the rotation are clearly depicted in the region of the arrows.

night before admission had increased the pain very markedly. He had never previously had constipation, bloody or tarry stools. On examination, the abdomen was moderately distended, tender and slightly spastic. Peristaltic sounds were increased in the left lower and upper quadrants, but were absent on the right. Survey roentgenograms of the abdomen revealed markedly distended loops of colon indicative of obstruction. Barium enema studies demonstrated a typical volvulus of the sigmoid and descending colon with a markedly distended loop of sigmoid between the two areas of torsion (Fig. 2, *A* and *B*). At operation performed later in the day, the volvulus was released and a Mickulicz resection performed. The patient recovered and was discharged well.

Case iii. M. L., female, white, single, aged seventeen. She entered the hospital complaining of pain in the abdomen and obstipation of one week's duration. She stated that she had always been constipated. Her bowels moved only about once a week and the movements were always very large. There had never been bloody or tarry stools. Three days prior to admission she began to have pain in the lower abdomen. The pain was dull and inconstant at the onset, but had become very severe and was accompanied by fever and chilly sensations. She had been

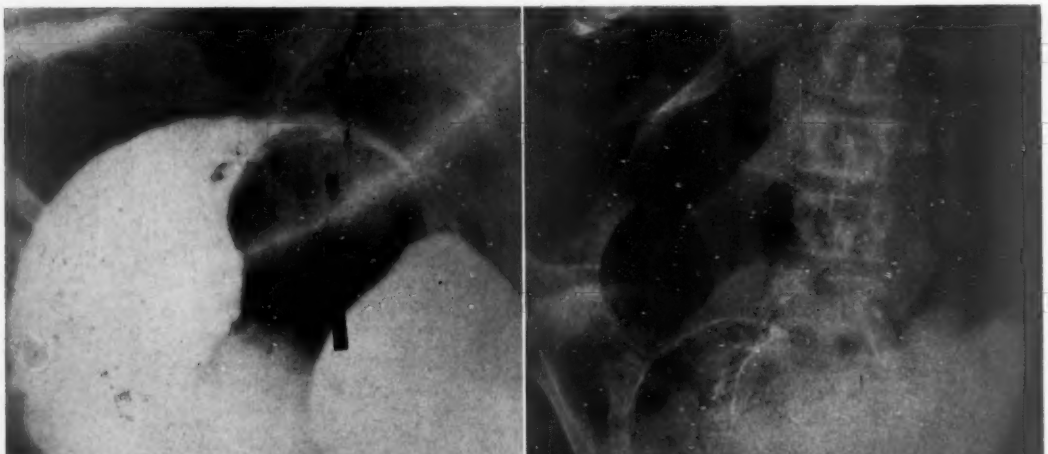

FIG. 5. Case v. *Volvulus of the sigmoid with obstruction. A*, barium enema study, spot roentgenogram made during roentgenoscopy. The involved area is indicated by arrows. The mucosal folds are arranged in spiral fashion. The sigmoid loop is markedly dilated. *B*, after evacuation of the opaque enema. The rectum is partially empty. The sigmoid loop is dilated and retains the opaque fluid. The proximal portions of the colon are markedly distended with gas.

nauseated and had vomited once. She had taken five cathartics and several enemas with no result. On examination, the abdomen was markedly distended and tympanitic. No masses were palpable. There was marked tenderness over the entire abdomen, more marked in the lower quadrants. Rectal and sigmoidoscopic examinations were negative.

The day following admission, roentgen studies of the abdomen revealed marked gaseous distention of the sigmoid and lower portion of the descending colon. A Miller-Abbot tube was passed and retained in position for three days without improvement of the patient's condition or relief of the distention. Prostigmine was ineffective. On the seventh hospital day, her condition became suddenly worse and immediate operation was deemed necessary. A 360°, clockwise rotation of the sigmoid was found. The loop was restored to normal position. There was localized gangrene of the sigmoid at the site of torsion and the colon proximal to the volvulus was markedly dilated, measuring about 5 inches in diameter. After resection of the gangrenous area, a colostomy was performed. About three weeks later, because of retracture and partial closure of the opening, a transverse colostomy was done. This was subsequently closed and the descending colon anastomosed to the rectum. The patient was later discharged well.

CASE IV. G. D., male, white, married, aged sixty-one. Four years ago the patient was operated on for "bowel obstruction," a transverse colostomy being done for megacolon with fecal impaction. The colostomy was closed about five months later. He was always very markedly constipated and had been admitted to the hospital several times because of severe obstipation. The present attack began with pain in the lower abdomen and marked distention three days prior to admission. He had had no bowel movement for seven days. He vomited one day ago, a foamy white material with no food elements or blood. The pain was colicky in character and severe. On examination, the entire abdomen was markedly and symmetrically distended with generalized tenderness but no spasm or rigidity. The liver edge was not palpable and no masses could be felt. Tympany

was present and peristalsis was audible and high pitched. There was no fluid wave. Rectal examination was negative. The white count was 7,200; hemoglobin 78 per cent; non-protein nitrogen 34.

Roentgen studies shortly after admission comprised survey roentgenograms of the abdomen, which revealed marked gaseous distention of the ascending and descending portions of the colon, consistent with intestinal obstruction. A barium enema examination twenty-four hours later showed volvulus in the region of the sigmoid with a characteristic corkscrew arrangement of the mucosal folds. At operation, a Mickulicz resection of the lower colon was performed, an internal hernia and volvulus being found. The pathologic report was as follows: The wall of the gut shows edema and infiltration with inflammatory cells; there is an acute peritoneal reaction. He made a good recovery and the colostomy was closed about two months later.

CASE V. F. V., female, white, single, aged seventy-three. The patient entered the hospital because of abdominal distention. At the time of admission she was incoherent and irrational, so that no history was obtainable. A relative accompanying her was also unable to supply any details except that during the past week there had been complaint of abdominal pain apparently originating in the left lower quadrant with radiation to the right side and increase in the size of the abdomen. Physical examination was also unsatisfatory because the patient was drowsy and uncooperative. There was tympany over the entire abdomen and a suggestion of a mass in the left lower quadrant. The abdomen was markedly enlarged and tense. She appeared poorly nourished and dehydrated. The white blood count was 9,000. Non-protein nitrogen was 75, blood chlorides 72, and CO_2, 49.

Roentgen studies of the colon revealed volvulus of the sigmoid with obstruction. Plasma was administered. The pulse became thready. Her condition was so poor that operation was deemed inadvisable. She became progressively worse and died eight days after admission to the hospital.

SUMMARY

Volvulus of the sigmoid is an important cause of intestinal obstruction. It is a condition in which early diagnosis is essential as the mortality is high unless the condition is relieved promptly. The palliative measures applied in other forms of obstruction are ineffective in cases due to volvulus.

Clinical diagnosis is usually impossible.

Barium enema studies offer a method of localizing the obstruction and demonstrating its cause. The characteristic roentgen findings in volvulus are linear, curved densities alternating with bands of increased radiance over an area several centimeters in length in the sigmoid colon. This corkscrew-like arrangement of the mucosal folds is pathognomonic of volvulus.

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ROENTGEN DIAGNOSIS OF DISEASES OF THE NECK OF THE BLADDER*†

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ALTHOUGH the urinary disturbances that make up the bladder neck syndrome (*Oeconomos*) are more frequent in the male climacteric and preclimacteric, they are also seen in infancy and adolescence.

In adulthood their presence indicates one of two frequent conditions: adenoma or cancer of the prostate.

In infancy and adolescence they always presuppose the existence of congenital anomalies of the prostatic portion of the urethra. If these are excluded, diseases of the neck of the bladder are considered and careful examinations made to determine the anatomical cause responsible and to permit of effective treatment.

For a long time the routine examinations (rectal palpation, sounding and cystoscopy) gave very little information on this subject but on the introduction of cysto-urethroscopy (cystoscopy by the McCarthy method) a great deal was accomplished in the diagnosis not only of those conditions which Legueu called dysfunctions of the neck and Marion disturbances of the neck, but also of the congenital anomalies and acquired defects to which the bladder neck is subject, though rarely.

Heitz-Boyer was the first to include urethrography in the methods of examination of these conditions, with the result that this and cysto-urethroscopy brought about great changes in this new field of urology.

In his writing on the subject in 1933 he does not discuss the roentgenological method nor describe the characteristics of the various types of disease.

Marion, discussant of the subject "Disturbances of the Neck of the Bladder" before the Fifth Congress of the International Society of Urology which met in London in 1933, restricted diagnosis to the investigation of the symptomatology and the routine methods of examination, from which he excluded cystoscopy.

Colombino also at the same Congress, referring to the question of diagnosis, considered only the cysto-urethroscopic appearance of certain types of disease of the neck.

Rubritius of Vienna, who devoted a great deal of attention to this subject, emphasizes rectal palpation, the manner of micturition, sounding and cystoscopy as methods of diagnosis, and cystometry (bladder manometry) for the purpose of investigating the function of the detrusor in the course of development of certain diseases.

Chwalla described four typical cystoscopies and in our country Meira discussed these, but did not refer to examination by urethrography.

None of the most authoritative authors on the subject, however, assign greater value to urethrography or urethrocystography in the diagnosis of any of the conditions that cause the diseases of the neck.

The cysto-urethrographic examinations made since 1936 in our patients with the bladder neck syndrome and described in our works "The propedeutic value of urethrocystography" published in the *Review of the Paulist Medical Association* in November, 1936, and "Contribution to the roentgen diagnosis of affections of the neck of the bladder," a preliminary note presented before the Section of Urology of the Paulist Medical Association August 25,

* Translation made by Audrey G. Morgan, M.D., Medford, Oregon.

† Read before the Section on Radiology of the Paulist Medical Association, January 22, 1944.

1940, show the undeniable value of such examinations, not only in the individualized diagnosis of the clinical forms of adenoma of the prostate, but also of the conditions which constitute the true affections of the bladder neck (congenital anomalies and acquired deformities) and those which most frequently cause the so-called diseases of the neck of the bladder.

Most authors do not give a clear description of each anatomical condition responsible for the dysfunctions of the bladder neck; there is even a certain confusion in considering some of them, such as hypertonia and sclerosis, fibrosis and hypertrophy of the trigonal muscle.

But clinical, cysto-urethoscopic and cysto-urethrographic examinations, transvesical surgical inspection of the neck and histopathological examinations furnish means of differentiating the following anatomical conditions which cause the so-called diseases of the bladder neck and their well known syndrome.

A. *Valves of the Neck* (valvula coli), resulting from an atrophy or congenital hypoplasia of the prostate gland and which are differentiated into:

1. (a) Valves without gland substance
   Formed only by mucosa (mucous valves)
   Formed of mucosa and muscle (muscular valves)
   (b) Valves with gland substance (musculoglandular valves).
2. Great development of the circular bundles but without a projecting border which acts as a valve (Englisch).

B. *Congenital atrophy of the neck* which is based on absence or congenital hypoplasia of the prostate. The internal opening of the urethra is punctate and the prostatic part of the urethra short and not very well developed, or very much elongated. Sometimes the colliculus seminalis is hypertrophied (Athayde Pereira).

C. *Acquired atrophy of the neck* resulting from:

(a) senile atrophy of the prostate
(b) absence of the prostate from extirpation
(c) atrophy of the prostate from castration or disease of the testicles
(d) atrophy from suppuration of the prostate
(e) traumatic atrophy of the prostate.

In these conditions the bladder neck (internal opening of the urethra and sphincter of the bladder) is involved in the pathological process and loses its normal characteristics.

D. *Sclerosis of the neck* based on inflammatory atrophy (contraction) of the prostate (chronic disease) and the forms of chronic prostato-vesiculitis with fibrosis and retraction (v. Lichtenberg-Heckenbach).

This is a transformation of the contractile element of the sphincter of the neck into cicatricial tissue resulting from acute or chronic inflammation (inflammatory and cicatricial atrophy).

There is loss of contractility, excess of connective tissue and atrophy of the submucosa to the degree to which the mucosa becomes cicatrized.

The names which some authors have given this condition of cicatricial sclerosis and inflammatory fibrosis of the neck result from this.

This appearance may be found also in cancer of the prostate (scirrhous).

Here we must consider:

(a) Genuine sclerosis (sclerosis of the internal opening of the urethra), sclerosis of the sphincter (inflammatory) and the sclerosis of senile involution.
(b) The glandular sclerosis (pseudosclerosis) of adenoma without hypertrophy (adenoma of the prostatic glands properly speaking and rarely "very minute intraprostatic adenomata").
(c) Sclerosis following prostatectomy (permanent tampon); endoscopic resection and electrocoagulation of the neck.

E. *Hypertonia of the sphincter of the*

neck (rigidity of the sphincter—Chwalla, contracture of the neck of the bladder—Chetwood) which may be transitory or permanent, and which may bring about functional hypertrophy of the sphincter (hypertrophic ring of the internal opening of the urethra—Englisch).

The substrate of hypertonia may be:

(a) Inclusions of micro-adenomata in the sphincter which irritate it and provoke contracture.

(b) Defective innervation of the sphincter.

(c) Existence of subacute or chronic inflammation of neighboring organs (prostate and seminal vesicles).

Rubritius includes also:

(1) Idiopathic hypertonia of rather obscure etiology to which many authors attribute a congenital origin and find it only in young people.

(2) Hypertonia of central origin (transitory or permanent) in the beginning of tabes, in myelitis, multiple sclerosis, trauma of the medulla and the myelodysplasia of spina bifida occulta.

In the syndrome caused by the latter, tenesmus supplants the other symptoms.

F. *Hypertrophy of the trigonal muscle.* This has been studied thoroughly by Young, Hinmann and Wesson, under the name, however, of fibrosis of the neck, but distinct from inflammatory fibrosis.

Rarely it originates in congenital defect but in the majority of cases it is acquired. The compensatory hypertrophy is the result of the muscular force required for the constant opening of the bladder orifice (internal opening of the urethra) obstructed for a shorter or a longer period or permanently, by some obstacle to the passage of the urine.

It is also called "median bar" and is frequently accompanied by hypertrophy of the interureteric ligament (interureteric torus, Mercier's bar).

Fasciculated bladder and pulsion diverticula are the effects on the detrusor, while the urinary syndrome (dysuria, pollakiuria and retention) results from dysfunction of the sphincter and the condition of the detrusor.

Hypertrophy of the trigonal muscle is a compensatory condition which may disappear with removal of the obstacle (calculus of the prostatic urethra, stricture of the urethra, adenoma of the median lobe and sclerosis of the neck itself).

Hypertrophy of the trigone after a time becomes an obstacle to micturition, resulting in a serious exacerbation of the above mentioned neck syndrome (dysuria, pollakiuria, tenesmus of the bladder and the neck and retention of urine).

This hypertrophy finally becomes transformed into a valve with a posterior recess by the dorsal elevation of the muscular part of the trigone, including the interureteric ligament.

The more urine accumulates in the bladder, the more impossible its physiological evacuation becomes.

For the roentgen diagnosis of these conditions it is necessary to prepare the patient with a thorough irrigation of the rectum.

The presence of fecal masses or gas in the ampula interferes with the examination by superimposing spots on the image of the bladder neck, which is to be studied particularly.

The technique used by us* is based on:

(a) The previous filling of the bladder for the purpose of demonstrating its whole internal outline, particularly that of the basal portion. Sixty to 80 cc. of contrast medium is injected. When there is residual urine the emptying of the bladder by sounding should precede the filling with contrast medium.

(b) The filling of the whole length of the urethra with 15 to 20 cc. of contrast medium. A syringe holding 20 cc. is used for this purpose, the piston of which should slide easily and to which is attached a rub-

* Pereira, A. Contribution to the roentgen diagnosis of affections of the bladder neck; preliminary note. Urological Section of the Paulist Medical Association, August 25, 1940.

ber tip capable of closing the meatus of the urethra.

(c) A roentgenogram made exactly at the termination of the filling of the urethra.† This makes it possible to obtain a clear view of the prostatic urethra and a perfect image of the internal opening of the urethra with the changes which will identify the various types of dysfunction and other diseases. The injection should not be too rapid nor yet too slow. Care must be taken not to use violence so as not to impair the clearness of the roentgen image and not to cause rupture of the bulb with arteriovenous reflux.

Positions. From the point of view of systematizing the examination two positions are used: (*a*) oblique or semiprofile (in which the image of the prostatic urethra is detached from that of the symphysis pubis); (*b*) anteroposterior, or from in front. In the first the patient is placed in dorsolateral decubitus, preferably right, with the hip flexed and in forced abduction, while the opposite leg is extended, holding the foot of the flexed leg. In the anteroposterior position the patient lies in dorsal decubitus.

Centering the roentgen tube on the pubis the roentgenogram is made according to the special requirements of each apparatus (milliamperage, exposure time and kilovoltage, which vary with the thickness of the patient's body).

In the anteroposterior position better images are obtained with an axial incidence of the rays on the pelvis (Sgalitzer's method).

Though there is a great deal of discussion in regard to the qualities and the preference to be given to the various contrast media used in the examinations (thorotrast, uroselectan and perabrodil, 20 per cent lipiodol or neoiodopin, 15 per cent sodium iodid, 30 per cent suspension of neobaryta, barium sulfate and citobarium, some of them dangerous, others irritating, some expensive) we prefer a suspension of luxbarium,* made by the Spic Laboratory of São Paulo, because of its low cost, ease of preparation, chemical harmlessness and perfect tolerance.

The suspension is prepared at the time of using by adding 30 gm. of the powder to 100 cc. of boiling water in a vessel previously heated.

Roentgen Diagnosis. Having obtained the two roentgenograms, profile and anteroposterior, the interpretation or roentgen diagnosis must then be made. It is the urologist who is best fitted to make this examination and interpret it most accurately. He knows the clinical history of the patient, has made the necessary examinations and knows what is to be proved or disproved.

With regard to the diagnosis of diseases of the bladder neck the following will have to be considered: (*a*) the filling characteristics of the bulbar, membranous and prostatic urethra; (*b*) the shortening, lengthening, deformities, dilatations and angulations of the prostatic urethra (supra- and inframontanal parts); (*c*) the appearance of the internal opening of the urethra, its position in relation to the bladder cavity, its borders; (*d*) the configuration of the elevations of the basal plane of the bladder, and (*e*) the completeness, clearness and deformities of the internal outline of the bladder (Fig. 1, 2, 3, 4 and 5).

The roentgen diagnosis will result from the detailed observation of the points mentioned above, taking into consideration the characteristics of the prostatic urethra, of the internal opening of the urethra of the basal plane and the outline of the cystogram. The roentgenogram not only furnishes elements for the diagnosis of diseases and their effects on the bladder (detrusor), but if these are lacking it gives evidence of the plastic tonus, hypertonia, paresis or complete atony of the bladder.

Nevertheless the interpretation will be arrived at by a careful inspection of the combined results of cystography and urethrography which will be completed by the

† Based on the principle of cerebral arteriography of Egas Moniz of Lisbon.

* Base barium sulfate.

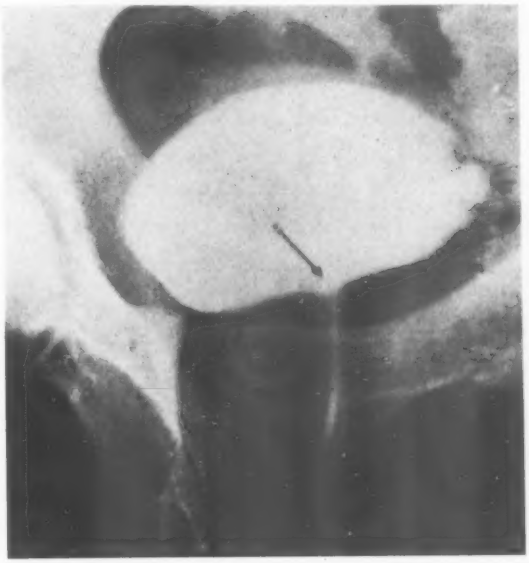

Fig. 1, 2, 3, 4 and 5. Normal bladder neck.

Fig. 1. E. M., aged forty-four. Relative impotence. Profile roentgenogram.

clinical history of the patient and sometimes by other routine examinations (palpation, sounding, cysto-urethroscopy).

In diseases of the neck it is only possible to fix roentgenologically three images which correspond to anatomical conditions:

1. *Image of the plane neck* (Fig. 6 to 13) without protruding borders in both the profile and anteroposterior roentgenograms. It represents a hypoplasia of the sphincter and of the tissues which form the borders at the internal opening of the urethra, or a retraction from sclerosis both of these tissues and of the sphincter itself. It corresponds to both congenital and acquired atrophy and to sclerosis of the neck.

Fig. 3. M. M., aged forty-four. Latent prostatitis and exaggerated dilatation of the prostate gland. Profile roentgenogram.

The differentiation between them can only be made by clinical examination in association with some roentgen characteristics of the prostatic urethra.

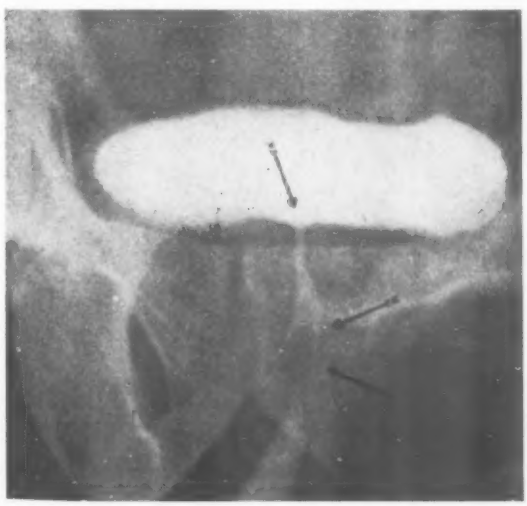

Fig. 2. J. P., aged forty. Varicocele, relative impotence. Profile roentgenogram.

Fig. 4. E. A., aged fifty-six. Relative impotence, latent adnexitis. Profile roentgenogram.

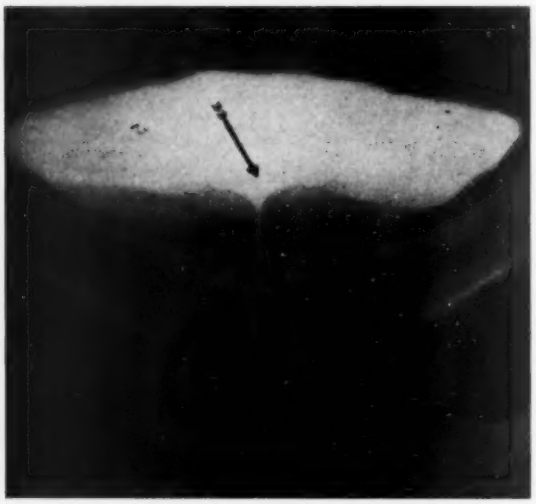

Fig. 5. C. G., aged forty. Relative impotence, hypertrophy of the colliculus. Anteroposterior roentgenogram.

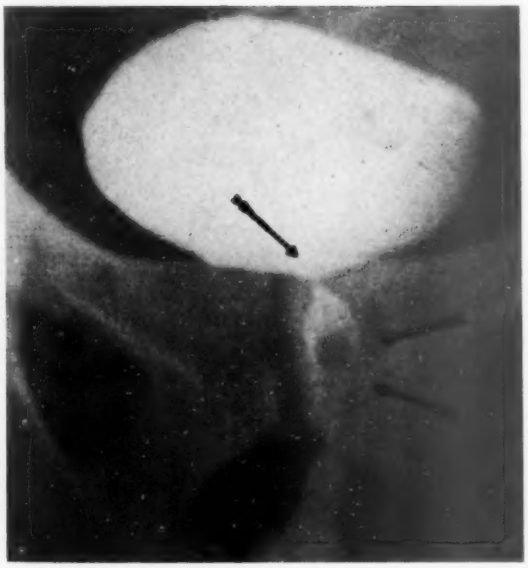

Fig. 7. B. S., aged forty. Plane neck. Congenital hypoplasia of the neck and prostate. Hypertrophy of the colliculus. Profile roentgenogram.

(a) In congenital atrophy the prostatic urethra is short, or slender and much elongated. Sometimes the colliculus seminalis is hypertrophied.

(b) In acquired atrophy the internal opening of the urethra is changed, but the prostatic urethra may keep its proportionate dimensions (coagulation of the neck, partial or total resection).

In the atrophy of senile involution with reduction of the size of the prostate, obviously the prostatic urethra is shortened.

(c) In sclerosis of the bladder neck,

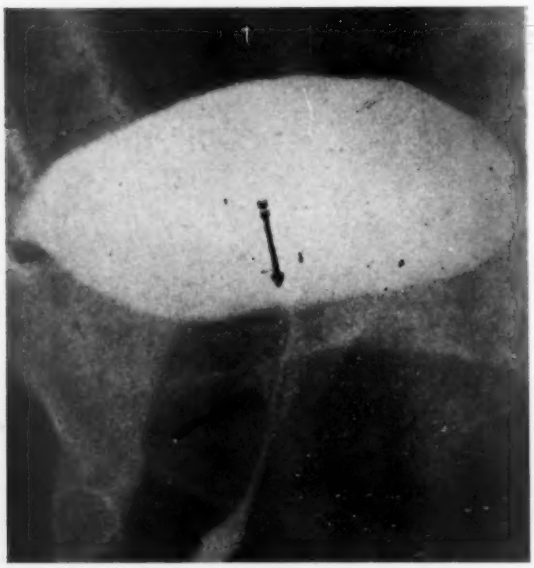

Fig. 6. E. C., aged forty. Plane neck. Congenital hypoplasia of the neck and prostate. Profile roentgenogram.

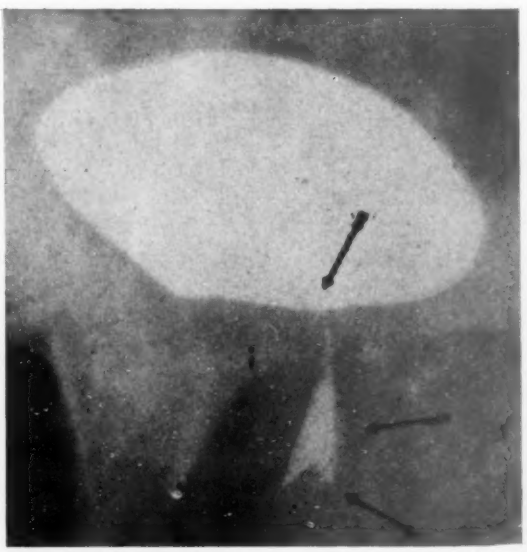

Fig. 8. E. R., aged thirty-eight. Plane neck. Congenital hypoplasia of the neck and prostate. Profile roentgenogram.

Fig. 9. N. R., aged twenty-nine. Plane neck. Congenital hypoplasia of the neck and prostate. Hypertrophy of the colliculus. Profile roentgenogram.

shortening generally occurs because of the inflammatory retraction of the prostate gland.

The image is identical in the profile and anteroposterior roentgenograms. It shows a punctate smooth neck in the fundus of the bladder which does not change under anesthesia (operative verification).

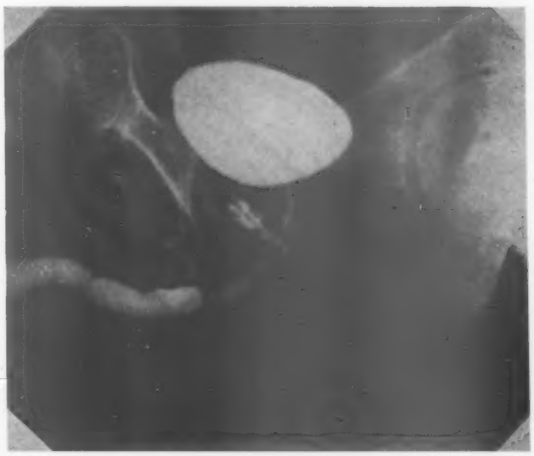

Fig. 11. V. S., aged thirty-six. Plane neck. Inflammatory atrophy of the neck and prostate. Stricture of the urethra. Profile roentgenogram.

2. *Fish-mouth image* (Fig. 14 to 18). This represents exaggerated growth of the borders into the bladder cavity and corresponds to an exaggerated tonus of the sphincter. The image corresponds also to what is seen in the neck when the bladder is opened. But under local anesthesia more than under spinal or general anesthesia, the sphincter relaxes and the protrusion disappears. It is therefore a transitory image and exists only when there are attacks of hypertonia of the sphincter.

Fig. 10. The same case as in Figure 9. Anteroposterior roentgenogram.

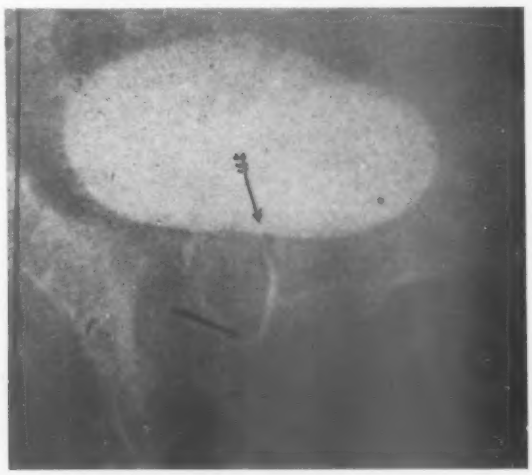

Fig. 12. E. B., aged sixty-eight. Plane neck. Atrophic prostate, sclerosis of the neck, hypertrophy of the colliculus. Profile roentgenogram.

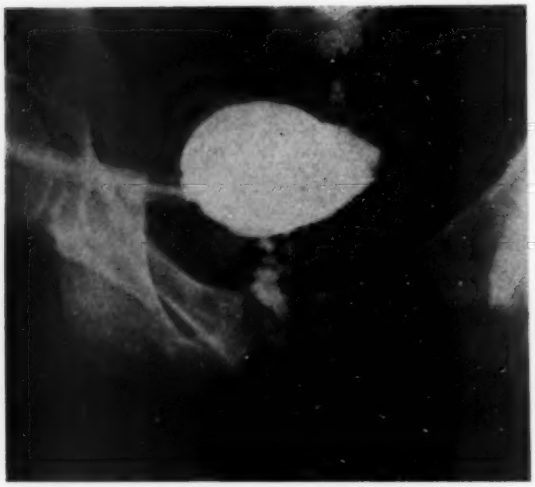

Fig. 13. M. S., aged fifty. Plane neck. Atrophic prostate, sclerosis of the neck, urinary infection. Profile roentgenogram.

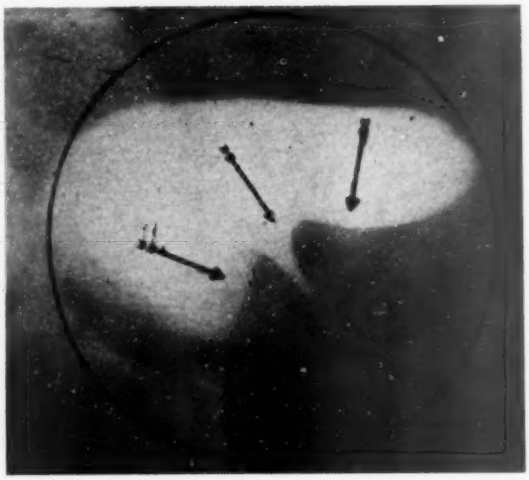

Fig. 15. The same case as in Figure 14. Enlarged image.

In certain diseases of the medulla the hypertonia becomes permanent and in that case the image persists and is not changed by any kind of anesthesia.

It is reproduced better in the profile than in the anteroposterior roentgenogram and always shows an elongation of the image of the prostatic urethra.

3. *Image of hypertrophy of the trigonal muscle* (Fig. 19 and 20). Here the tissue which corresponds to the trigonal muscle (seen in profile) is increased and tends to invade the bladder. In this growth it extends along the prostatic urethra and deviates the internal opening of the urethra so that it projects forward. As it is a progressive condition, in the early stages the prostatic urethra is not changed and the muscle protrusion is barely perceptible.

The roentgen image faithfully reproduces these appearances but only in the profile roentgenogram. The posterior border of the internal opening of the urethra grows forward and becomes superimposed on the

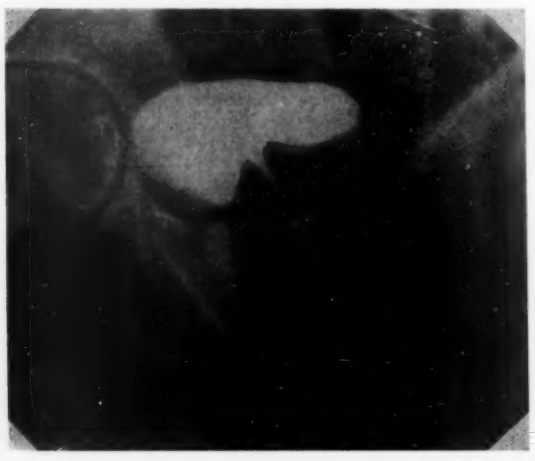

Fig. 14. B. M., aged sixty-four. Hypertonia of the sphincter, subacute prostatovesiculitis. Profile roentgenogram.

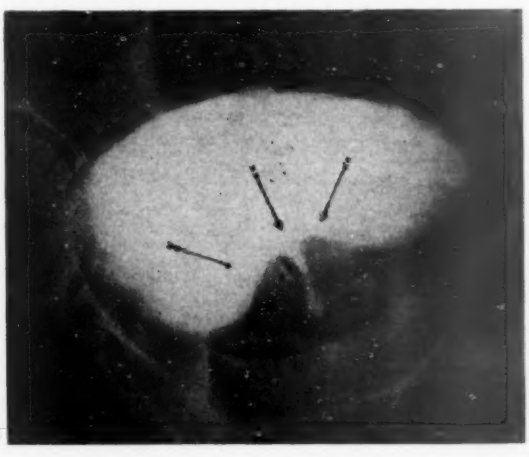

Fig. 16. M. M., aged twenty-eight. Hypertonia of the sphincter, subacute prostatovesiculitis. Profile roentgenogram.

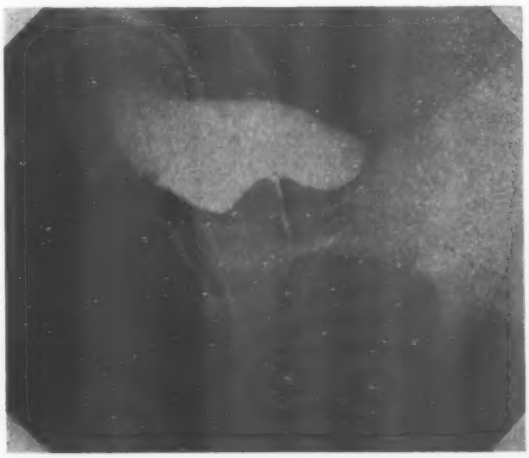

Fig. 17. A. F., aged forty-seven. Hypertonia of the sphincter, subacute prostatovesiculitis. Profile roentgenogram.

anterior border, even forming a sort of valvular tongue.

In the anteroposterior roentgenogram taken in the advanced stages the image may resemble that of adenoma of the median lobe in the beginning of its growth.

When the hypertrophy of the median lobe coincides with hypertrophy of the trigonal muscle the image does not show anything characteristic except the protrusion of the adenoma itself.

Among 20 cases of disease of the bladder neck examined the following roentgen forms were seen:

	Cases
Congenital atrophy of the neck	4
Acquired atrophy	1 (trauma)
Sclerosis of the neck	6
Hypertrophy of the sphincter	6
Hypertrophy of the trigonal muscle	3

In 4 cases surgical operations to which the patients were subjected showed that the roentgen images corresponded exactly to the surgical findings (plane neck with punc-

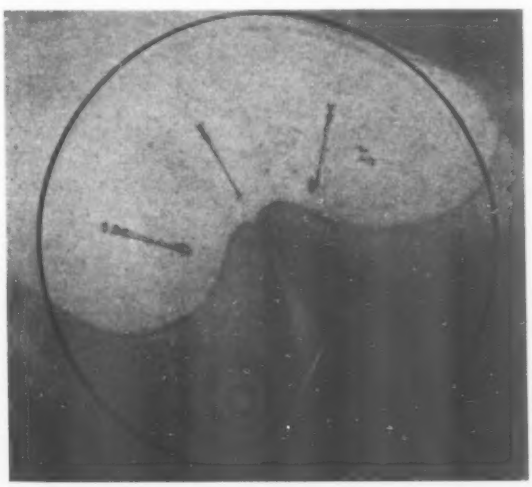

Fig. 18. J. A., aged fifty-eight. Hypertonia of the sphincter with a subacute exacerbation. Profile roentgenogram; image enlarged.

Fig. 19. J. M., aged fifty-eight. Hypertrophy of the trigonal muscle, stricture of the urethra, prostatovesiculitis. Profile roentgenogram.

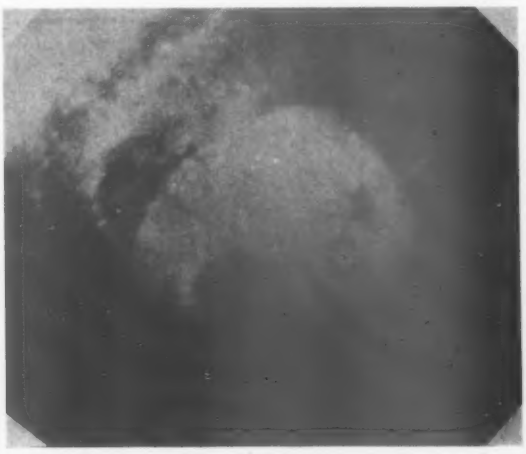

Fig. 20. P. S., aged sixty-one. Hypertrophy of the trigonal muscle, total stricture of the urethra, urinary infection, tabes. Profile roentgenogram.

tate orifice, protrusion of the mucosa of the neck into the bladder and valvular protrusion of the posterior border of the neck).

In a case of hypertrophy of the trigonal muscle operated on by Blatt's technique (cuneiform resection) the characteristic histopathology of the excised segment was found (muscular hypertrophy and interstitial fibrosis).

A cystogram obtained in conjunction with urethrography in some cases showed disease of the detrusor, such as hypertrophy (fasciculated bladder), pulsion diverticula and the image of paretic bladder (the detrusor does not accommodate itself by plastic tonus to the contrast medium injected into the bladder and the image loses its clearness of outline, particularly in the free parts of the bladder).

Accidents during Urethrocystography. Although these examinations are carried out by specialists accidents do occur to which attention should be called: (*a*) small infractions of the mucosa of the prostatic urethra from distention during filling; (*b*) fissuring of the bulbar cul-de-sac from distention if the injection of contrast medium is continued when there is spasm of the striated sphincter; (*c*) even rupture of the bulbar cul-de-sac with urethrovenous reflux or extravasation of the injected contrast medium; (*d*) reactivation of latent inflammatory processes in the prostate and seminal vesicles as well as recurrences of pre-existing pyelonephritis.

Contraindications. In the roentgen diagnosis of diseases of the neck of the bladder there are contraindications to cystourethrographic examination which may be summarized as follows: (*a*) when there is recent trauma resulting from instrumental examination with or without loss of blood (danger of reflux and its serious consequences); (*b*) in patients with acute or recent gonorrhea; (*c*) in the course of acute adnexitis (recurrent prostatovesiculitis) with attacks of hypertonia; (*d*) in acute attacks of cystitis; (*e*) in the course of regression of abscess of the prostate opening into the urethra.

CONCLUSIONS

From a number of patients examined in whom the diagnosis of disease of the neck of the bladder could be made by roentgenography, we conclude that urethrocystography as practiced by us is necessary and even indispensable in the examination of these patients:

(a) Because it permits of an accurate differentiation between the different anatomical conditions and anomalies of the neck responsible for disease.

(b) Because it permits of differential diagnosis from adenoma of the prostate, particularly that of the median lobe.

(c) Because it makes it possible to determine the condition of the detrusor during disease, showing its hypertrophy, pulsion diverticula and the sign of paretic bladder.

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HOW EXACT IS THE ROENTGEN DIAGNOSIS OF HEART VALVE CALCIFICATIONS?

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EXCEPT for statements of Sosman no publications concerning the exactness of the roentgen diagnosis of heart valve calcifications seem to exist. Sosman reports the diagnostic results in 20 patients, where calcifications were demonstrated roentgenologically; in every case massive calcium deposits were found at autopsy. There was one diagnostic error in interpretation, a deposit of calcium in the aortic valve being interpreted as calcification in the coronary arteries. This was a positive error of 5 per cent. The negative error was much greater, as often cases of chronic valvular disease were seen with small or moderate-sized calcium deposits in the injured valves which had been overlooked or missed at roentgenoscopy. Recently Sosman has stated that the positive roentgen findings were now confirmed at autopsy in every case; no records as to the actual extent of error in the negative roentgen diagnosis are found in this article.

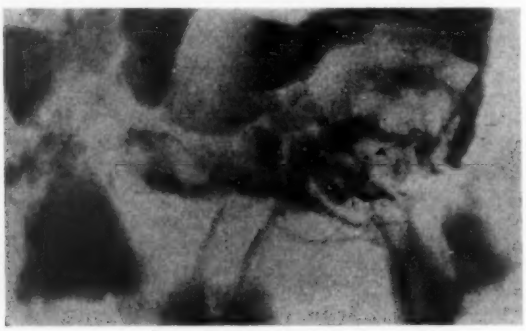

FIG. 1. Autopsy specimen (roentgenogram). Four small calcareous deposits in the mitral valve; the largest of these was diagnosed while the patient was still living.

We have been able to control our positive or negative roentgen findings in 33 patients. This material* includes only cases with autopsy-verified alterations of the valves, which are calcareous in 11 and non-calcareous in 22 cases. The alterations are due either to endocarditis or to syphilis. Cases with atherosclerotic affections of the valves are not included in this material; neither are cases with intact valves in non-valvular heart disease. Our results were the following: from 8 cases of calcification in the mitral valve 6 were found and 2 were missed at roentgenoscopy, 2 cases of calcification in the aortic valve were both found, and 1 further case of calcification in both the mitral and the aortic valve was missed at roentgenoscopy. In one of the diagnosed cases the calcareous deposit seen during life was found to be only 1.5×2 mm. at autopsy (Fig. 1). In cases with non-calcareous alterations the roentgenological record always has been negative. Thus we had our positive roentgen findings confirmed at autopsy in every case, while the error of the negative diagnosis was 12 per cent. We usually used 90 kv. (peak) and 3 ma. in chest roentgenoscopy.

Errors in the roentgen diagnosis may be caused by the method (massive pleural effusions, which make it difficult to see details; corpulent patients). Most of the errors, however, are caused by the roentgenologist himself, e.g. if he is tired, if he has not adapted his eyes adequately, or if for some cause he cannot work with full attention. Once, after night service in the medical department, I in spite of all care missed a mitral calcification; a few days later I diagnosed it in the same patient at a glance. I have looked for the dates when the errors happened; in 2 of our 3 overlooked or missed cases the roentgenologist probably found it difficult to concentrate.

The purpose of this publication is to show the actual extent of error in the negative roentgen diagnosis of heart valve calcifications, and also to confirm the state-

* Collected at the I. Medical Clinic of the University Tartu.

ments of Sosman as to the accuracy of the method.

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THE EFFECTS OF BETA IRRADIATION ON THE RABBIT'S EYE*

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PREVIOUS studies on the effect of irradiation on the eye have been concerned largely with roentgen rays and gamma rays of radium. Clinically, the beta rays of radium have been used extensively in ophthalmology for the treatment of a wide variety of conditions affecting the conjunctiva and cornea. The dosages used for such treatments have been determined empirically without satisfactory knowledge of the range of tolerance of the normal ocular tissues for a single dose of beta irradiation or the cumulative effects. Also, individuals may show apparent differences in tissue sensitivity to beta rays.

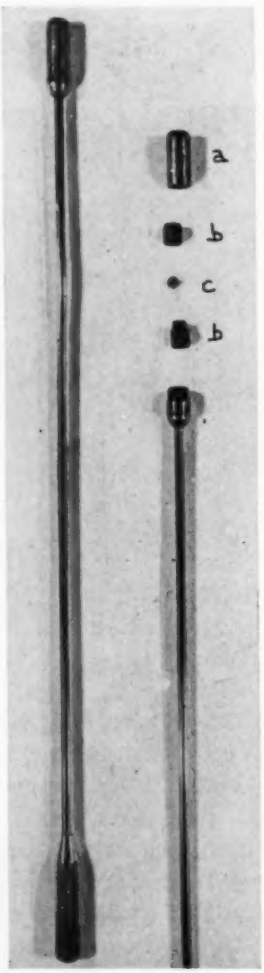

FIG. 1. Photograph of the Burnam beta-ray applicator with a side view of the disassembled tip showing (*a*) the brass holder with walls 2 mm. in thickness, (*b*) container for the glass capsule, and (*c*) glass capsule containing the radon.

The effective use of beta irradiation requires an exact knowledge of the differential between the sensitivity of normal tissues and the pathologic tissues to be treated. It is the purpose of this study (1) to standardize the technique of applying beta irradiation to the eye, controlling such factors as the distance of the applicator from the eye, the size of the area irradiated, and the site of application; (2) to determine the tolerance of the normal tissues of the anterior ocular segment for beta irradiation; and (3) to describe the clinical and pathologic characteristics of the lesions produced by various doses with special references to the differences in reactivity between the cellular components of the conjunctiva and cornea.

The absolute dosages determined for the rabbit's eye in these experiments are not necessarily applicable to the human eye. However, the important features in the technique of application, the differences in sensitivity between various cellular components, the principles of cumulative effects, and the general characteristics of beta irradiation burns are probably similar in the rabbit and human eye.

MATERIALS AND METHODS

The Burnam applicator[1] for beta irradiation was used in these experiments (Fig. 1–3). In this applicator, the glass capsule containing the radium emanations or radon

* From the Wilmer Ophthalmological Institute of the Johns Hopkins Hospital and University, Baltimore, Maryland.

is held in a brass tube of walls 2 millimeters in thickness. This prevents the escape of beta rays except through a 4 mm. opening at the end of the applicator. The glass bulb containing the radon is located 1 mm. from the end of the tube, and the thickness of the glass is sufficient to prevent the escape of alpha particles. Gamma rays are emitted simultaneously with the beta rays but only in comparatively low concentration, a ratio of approximately 100 electrostatic units of ionization produced by the beta rays to 1 unit produced by the gamma rays. Accordingly, therapeutically useful doses of beta rays can be applied without significant gamma irradiation.

In early experiments, the applicator was held either manually or fixed in a ring stand

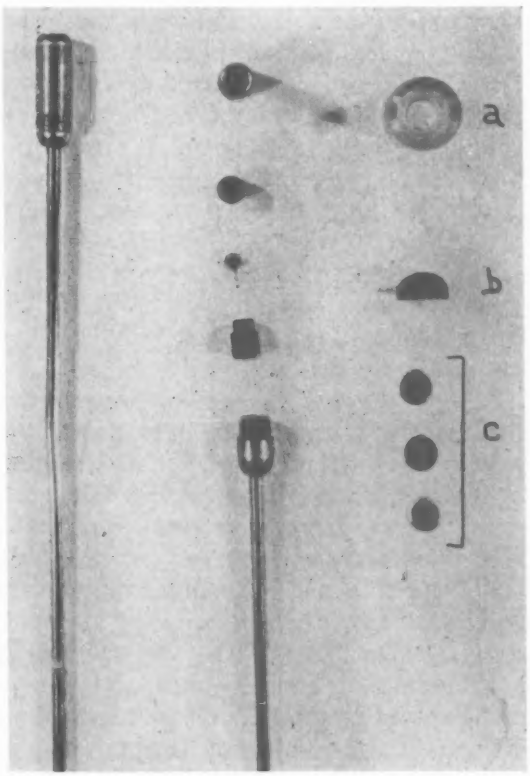

FIG. 2. Photograph of the Burnam beta-ray applicator, an end view of the disassembled tip, and (*a*) an end view of the lucite contact glass holder for the head of the applicator, (*b*) semicircular lead protector for localization of the irradiation, and (*c*) aluminum filters which can be inserted into the lucite holder.

FIG. 3. Photograph showing treatment of the proptosed rabbit's eye with Burnam beta-ray applicator and lucite contact glass.

about 5 mm. above the rabbit's eye. Although the rabbits were anesthetized with ether during treatments, the eyes could not be kept entirely stationary. In order to eliminate such variations in the distance of the applicator from the eye and the size of the area treated, a contact glass holder made of lucite was designed for the beta applicator (Fig. 2 and 3). When this was placed directly on the rabbit's eye, the glass bulb containing the radon was held constantly 6 mm. above the site of application (Fig. 3), and an area 11 mm. in diameter was exposed. In some experiments, thin discs of aluminum were inserted into the upper part of the contact glass to screen out part of the beta rays. To protect the cornea during the treatment of a sector of the limbus, a semicircular piece of lead was inserted into the end of the contact glass in certain experiments.

In these experiments, the dose of beta irradiation has been recorded in terms of gram-seconds of radium because of the ease with which the time exposure in seconds can be calculated from the strength of the radium in milligrams or its equivalent of radon in millicuries; for example,

$$\text{No. sec. exposure} = \frac{\text{No. gram sec. desired} \times 1000}{\text{No. mg. radium or No. millicuries of radon.}}$$

For conversion into the international dosage unit "milligram-hours" the number of gram-seconds must be multiplied by the factor 0.278 thus:

$$\text{No. milligram-hours} = \text{No. gram-seconds} \times \frac{1000}{60 \times 60}.$$

Mongrel rabbits were used except albino or black animals. The weight of the rabbits ranged between 4 and 6 pounds, and all the animals were at least four months old. During treatments under ether anesthsia, the eyes were popped out between the lids and maintained in that position by clamping the lids behind the globe.

A numerical estimation of the severity of the lesions produced by beta burns was made by using a modification of methods previously outlined[2] (see Table I).

TABLE I

SCALE FOR GRADING THE SEVERITY OF OCULAR LESIONS PRODUCED BY BETA IRRADIATION

	Maximum Grade
Corneal	
Opacification: density × area = 4 × 4	16
Vascularization:	3
Ulceration: +4 = perforation = 100% corneal lesion regardless of other values	4
Edema:	3
Total points for estimation of corneal lesion	24 = 100%
Duration of corneal opacity: 14 days and over	4
Conjunctival	
Redness	2
Edema	3
Necrosis (petechial hemorrhages or ischemia)	2
Mucopurulent discharge	2
Iritis	3
Total points for estimation of ocular lesion	40 = 100%

"Maximum ocular reaction" = sum of the maximum values for each symptom during the course of observation, and conversion of the total to a percentage figure. This gives an index of the acuteness of the reaction.

"Final corneal opacity" = sum of the values of the corneal symptoms on the last day of observation, a total of 24 points or corneal perforation representing a 100% lesion. If the cornea became clear, the day on which this occurred is recorded.

STANDARDIZATION OF TECHNIQUE AND DOSAGE

1. *Without Contact Glass Applicator.* Twenty-four normal rabbit eyes were exposed to varying doses of beta irradiation holding the Burnam applicator as steadily as possible about 4–6 mm. above the center of the cornea. The ocular reactions following these exposures showed considerable variation in intensity. Doses of 100 gram-seconds or less produced little more than a transitory conjunctival reaction with punctate erosions of the corneal epithelium stainable with fluorescein. A transitory haziness of the cornea appeared after exposure to doses of 24 gram-seconds and over. Three eyes exposed to 200 gram-seconds developed moderately severe conjunctival and corneal lesions, and one cornea exposed to 250 gram-seconds had perforated by the twenty-fifth day.

2. *With Contact Glass Applicator.* When the beta applicator was held constantly by the contact glass 6 mm. above the center of the cornea covering an area of about 11 mm., the lesions were more severe than those produced without the contact glass holder (Table II). No significant corneal reaction followed an exposure of 18 gram-seconds. Exposures of 24–36 gram-seconds produced a faint haziness of the cornea with punctate staining by fluorescein. Exposures of 50 and 60 gram-seconds resulted in moderate corneal damage, still present after nineteen days. Eyes exposed to 75 gram-seconds developed rather severe conjunctival and corneal symptoms, resulting in perforation of the cornea in several instances.

3. *Comparison of Both Eyes in the Same*

Animal. A comparison of the severity of the ocular reaction produced by beta irradiation in opposite eyes of the same animal affords an estimation of the variability in technique of application. Both eyes of 5 rabbits were exposed to 75 gram-seconds using the contact glass applicator. The average difference in the maximum ocular reaction between the two eyes of each animal was only 6 per cent (standard deviation of the different values from the mean = 6 per cent). Only one rabbit showed any difference in the corneal opacity of the two eyes after 32 days, an average difference for the series being 1.6 per cent (standard deviation = 3 per cent). This indicates that the dosage of beta irradiation can be applied with some accuracy by this technique.

4. *Variation in Individual Sensitivity to Beta Irradiation.* A comparison of the ocular reaction produced by the standard dose of 75 gram-seconds among different rabbits revealed large differences in reactivity. A standard deviation of 16 per cent in the maximum ocular reactions was obtained for the differences between the 5 rabbits. Perforation of both corneas occurred in three animals, the other 2 rabbits having an average residual corneal opacity of 54 per cent and 46 per cent respectively. Therefore, a standard deviation of 25 per cent in the severity of the average final corneal opacity after thirty-two days was present in these 5 animals.

5. *Localization of the Lesion.* The damaging effect of beta irradiation appeared to be localized to the site of application, especially when smaller doses were used. The area of corneal opacification and edema was usually limited to the diameter of the contact glass. However, with doses of 75 gram-seconds or over, the lesion spread beyond the exposed area of 6 mm. and involved most of the cornea. These changes were somewhat late, and might be accounted for by secondary processes such as spreading of edema throughout the entire stroma, an inflammatory reaction, and corneal vascularization. When precautions were taken to protect the cornea, the limbal region tolerated an exposure of 75 gram-seconds, without secondary corneal involvement. One eye which received a single application of 200 gram-seconds at the limbus developed a maximum ocular reaction of only 31 per cent and a small

TABLE II

SEVERITY OF OCULAR REACTIONS PRODUCED IN NORMAL RABBIT'S EYES BY BETA IRRADIATION USING BURNAM APPLICATOR AND LUCITE CONTACT GLASS

Dosage and Site (No. gram-seconds)	No. Eyes	Maximum Ocular Reaction Per Cent	Final Corneal Opacity Per Cent	Day of Final Reading	Corneal Erosion
18 gm-sec. cornea	1	1	0	13	Doubtful
24 gm-sec. cornea	4	2	1	13–32	Slight punctate staining
30 gm-sec. cornea	4	2	2	13–32	Slight punctate staining
36 gm-sec. cornea	4	3	2	13–47	Punctate staining
36 gm-sec. limbus	1	1	0	47	Doubtful
50 gm-sec. cornea	1	17	16	19	Superficial
60 gm-sec. cornea	1	25	19	19	Superficial
75 gm-sec. cornea	10	72 (SD = 17)*	80 (SD = 25)	32	Perforation (6 eyes) Superficial (5 eyes)
100 gm-sec. cornea	1	33	35	19	Superficial
200 gm-sec. cornea	1	94	100	47	Perforation
200 gm-sec. limbus	1	31	12	47	Superficial

* SD = standard deviation of the mean.

opacity of the adjacent cornea. The opposite eye of this animal received 200 gram-seconds to the center of the cornea and developed a 94 per cent maximum ocular reaction with perforation of the cornea.

6. *Screening.* In a few experiments, aluminum discs of varying thicknesses were placed over the end of the beta-ray applicator within the contact glass holder. As to be expected, the intensity of the reaction was reduced; e.g., exposure of 300 gram-seconds through a 1 mm. filter produced only a superficial punctate erosion of the corneal epithelium, 300 gram-seconds with a 0.43 mm. filter produced a corneal lesion comparable to that seen after a 50–60 gram-seconds unfiltered exposure, and 300 gram-seconds with a 0.30 mm. filter produced a somewhat more severe lesion. The corneal epithelium was not completely spared by such screening. Application of 48 gram-seconds with a 0.30 mm. filter over the limbal region of a heavily pigmented rabbit's eye resulted in a migration of the limbal pigment over the surface of the cornea although no definite staining with fluorescein was detected. Histologically also, there was some disturbance of the corneal epithelium after exposure of the eye to 75 gram-seconds with the 0.30 mm. filter and to a less extent with the 1 mm. filter. No evidence was obtained that the filtered beta rays produced deeper lesions than the unfiltered beta rays, with relative sparing of the epithelium.

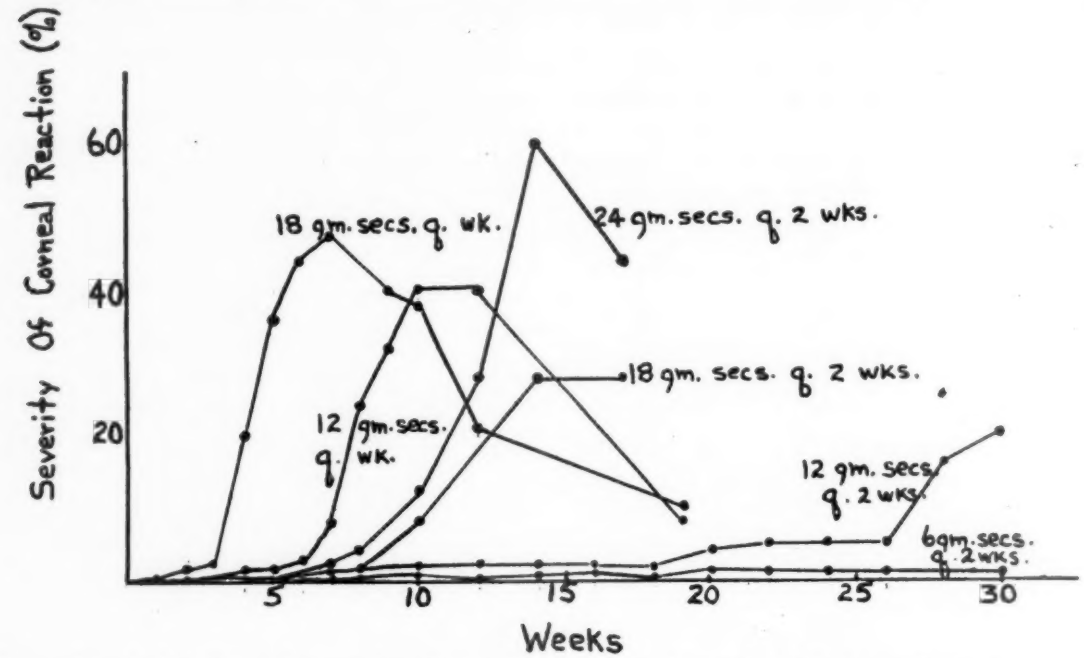

Fig. 4. Cumulative effects of repeated small doses of beta irradiation on the rabbit's eye. Each curve represents the average of two eyes in different animals. One rabbit proved resistant to repeated doses of 12 gram-seconds and 18 gram-seconds every week for ten weeks in opposite eyes, obtaining a maximum corneal reaction of 6 per cent and 10 per cent respectively. Exposures were discontinued two weeks before each maximum peak of reaction.

Using the contact glass with semicircular lead protector, a 75 gram-seconds exposure resulted in a minor semicircular opacity of the cornea, not only smaller but also less intense than that obtained without the lead protector.

CUMULATIVE EFFECTS

The possibility of cumulative effects after repeated exposures to irradiation is well recognized clinically. This phenome-

non was demonstrated in this study on rabbit corneas using varying doses spaced at one or two week intervals (Fig. 4). With applications weekly, corneal damage became manifest after four exposures of 18 gram-seconds, and an equally severe lesion developed after eight exposures of 12 gram-seconds. Biweekly applications of 24 or 18 gram-seconds produced a slight corneal lesion after five exposures and a moderate lesion after six exposures. Ten biweekly exposures of 12 gram-seconds induced a mild lesion and 14 exposures a moderate lesion. After 15 biweekly exposures of 6 gram-seconds, nothing more than a faint haziness of the cornea with irregular punctate staining with fluorescein was noted clinically.

The onset of the corneal lesion therefore appeared earliest after larger doses and after more frequent applications. Although no strict quantitative relationships can be elicited from these data, it required greater total dosages to produce equally severe (20 per cent) corneal lesions when either smaller individual doses were administered or when exposures were less frequent. This is probably dependent on the degree of recoverability of the tissues, most pronounced when the dosage of beta is low or when more time is allowed between treatments.

The individual doses used for these experiments did not produce significant clinical lesions in the rabbit's cornea, except for mild punctate staining of the epithelium with fluorescein. A series of histological preparations was therefore made to see if structural changes could be detected microscopically in the cornea at the end of one and two weeks following a single exposure to those small doses of beta; 6, 12, 18, and 25 gram-seconds respectively. All specimens showed changes in the epithelium, somewhat more pronounced at two weeks than at one week after exposure.

Histological sections were made of the eyes which had received 6 or 12 gram-seconds of beta radiation every two weeks for twenty-eight weeks, enucleation being performed four weeks after the last exposure. The two eyes which received repeated doses of 6 gram-seconds showed slight irregularity in the thickness of the corneal epithelium, and many cuboidal cells characteristic of regenerating epithelium. The corneal stroma appeared normal. Eyes which were exposed repeatedly to 12 gram-seconds showed advanced changes in both epithelium and stroma, including loss of stroma cells, edema and vascularization.

PATHOLOGY OF BETA IRRADIATION BURNS

Time of Onset. The time at which clinical lesions first appeared varied inversely with the dosage of beta irradiation applied to the rabbit's cornea. In general, signs of damage to corneal epithelium or stroma did not appear prior to one week after exposures of 36 gram-seconds or less. With doses of 75 gram-seconds or more, punctate staining of the cornea with fluorescein usually could be demonstrated within twenty-fours, but easily detectable haziness of the stroma ordinarily did not appear until after forty-eight hours. The onset of histological changes in the corneal epithelium also was directly related to the degree of exposure; definite changes after exposures of 6, 12, 24, 75, and 200 gram-seconds appearing at ten, seven, six, two and one days respectively.

Depth of Lesion. The dosage was also found to be related to the depth at which lesions appeared. Little more than a punctate staining of the corneal epithelium and questionable haziness of the stroma were produced by exposures of 18 gram-seconds or less. Transitory corneal haziness occasionally appeared after exposures of 24–30 gram-seconds, but 36 gram-seconds usually produced a slight but definite cloudiness of the stroma which cleared within a few weeks. Two eyes exposed to 50 and 60 gram-seconds respectively had persistent corneal opacification of 16 per cent and 19 per cent at the end of nineteen days. Exposures of 75 gram-seconds and over regularly produced clinical damage to the corneal stroma of such an extent that permanent corneal scarring remained. The

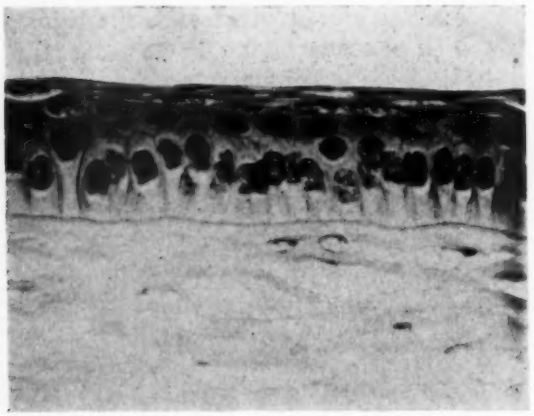

FIG. 5. Section taken eight hours after exposure of 75 gram-seconds, showing peg-shaped basal cells of corneal epithelium and anterior displacement of the nuclei.

severity of the iritis roughly paralleled the dosage, but this was probably related to the intensity of the associated corneal lesion. No irradiation cataracts were observed in any of these animals, some of which received as much as 250 gram-seconds to the cornea. None of the animals exposed to doses of 300 gram-seconds through aluminum filters 0.3 to 1.0 mm. in thickness developed cataracts, indicating that the amount of beta and gamma rays which might have penetrated through the cornea was insufficient to damage the lens.

Conjunctiva. The conjunctival reaction following application of beta irradiation to the center of the cornea consisted of a transitory edema and congestion lasting several days. Severe corneal burns were also accompanied by mucopurulent discharge in the conjunctival cul-de-sacs, probably a result of secondary infection. When relatively large doses of beta rays were applied directly to the bulbar conjunctiva (e.g., 18–24 gram-seconds with the applicator directly in contact with the conjunctiva), the necrosis of conjunctiva and superficial blood vessels was followed by scarring and contracture of the conjunctiva to such an extent that the cul-de-sacs were occasionally obliterated, with a fold of conjunctiva drawn onto the surface of the cornea.

Corneal Epithelium. Exposures as little as 6 gram-seconds produced changes in the corneal epithelium visible under the slit lamp, such as fine edema or bedewing, pitting of the surface stainable in punctate fashion by fluorescein, filamentary tags of loosened epithelium, and occasionally small bullae. Loosening and desquamation of the epithelium was uncommon except when associated with extensive damage to the underlying stroma. Regeneration of the epithelium was often accompanied by a migration of limbal pigment onto the surface of the cornea.

Histologically, the earliest changes in the epithelium visible at twenty-four hours after exposure to 75 gram-seconds consisted in an elongation of the basal cells with anterior displacement of the nuclei (Fig. 5). At forty-eight hours, the cell boundaries were in many places indistinct or absent, the cytoplasm had become increasingly rarefied, the cell nuclei showed minor variations in size and overlapped each other (Fig. 6). Seven days after exposure (Fig. 7), the normal arrangement of cells had become completely disorganized although epithelium remained attached to the underlying stroma. The nuclei showed extreme variations in size, for the most part being larger. The nuclear membranes remained intact, but the chromatin formed small darkly staining clumps in many cells. A few cells appeared to have two heavily staining

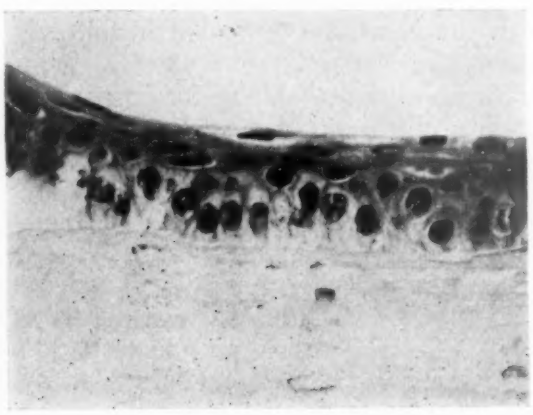

FIG. 6. Section of corneal epithelium taken forty-eight hours after an exposure of 75 gram-seconds.

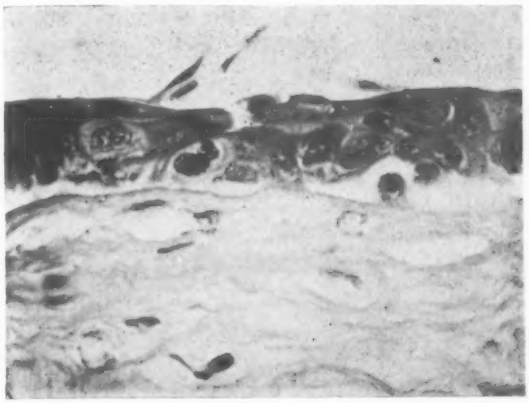

Fig. 7. Section of corneal epithelium taken seven days after an exposure of 75 gram-seconds.

nuclei within a single cell membrane. These changes do not appear after exposure of the cornea to 75 gram-seconds of gamma irradiation in which the beta rays have been filtered out by a brass screen 2 mm. in thickness. Extremely irregular formations of epithelial cell nuclei often remained attached to corneal stroma which was entirely acellular, vascularized or scarred (Fig. 8). The appearance of regenerating cells was often delayed for two to four weeks after exposure (Fig. 9).

Corneal Stroma. In burns severe enough to involve the corneal stroma, an edema

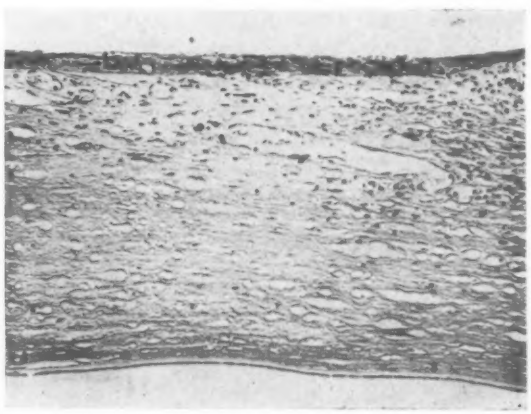

Fig. 8. Section of cornea taken near the limbus twenty-one days after exposure to 75 gram-seconds. There is no evidence of regeneration of the corneal epithelium. Superficial vascularization and a small number of inflammatory cells have entered the anterior layers of the cornea.

Fig. 9. Section taken thirty-two days after exposure to 75 gram-seconds. The corneal epithelium has regenerated over a heavily vascularized stroma.

first appeared in the superficial layers as clear areas with interspersed flocculent white spots (Fig. 10). Such edema usually spread into the deeper layers of the cornea, and to a variable extent laterally. Within

Fig. 10. Photograph of rabbit's cornea, ten days after exposure to 75 gram-seconds. The area of exposure exhibits only a mild haziness with edema of the stroma.

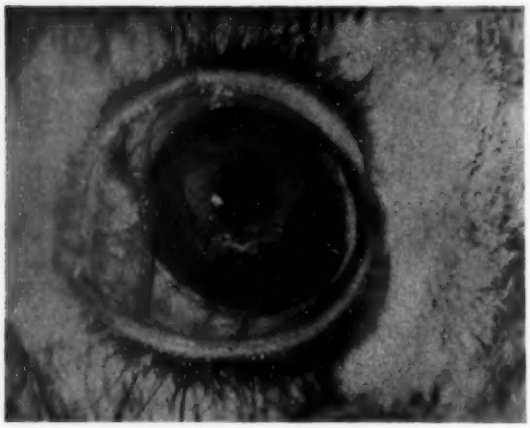

FIG. 11. Photograph four weeks after an exposure to 300 gram-seconds using a 0.43 mm. aluminum filter. Extreme edema of the stroma has developed into a staphyloma, some crystalline deposits are present below and the cornea is heavily vascularized.

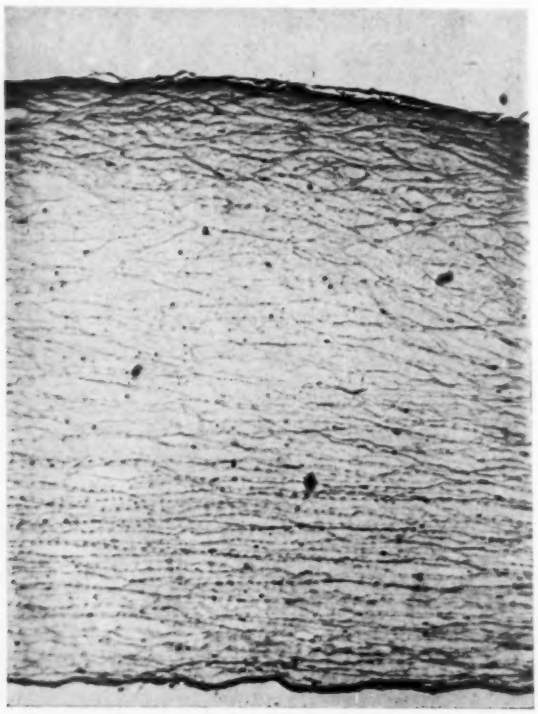

FIG. 12. Section taken fourteen days after exposure to 75 gram-seconds, showing loss of all but a few remnants of corneal epithelium, disappearance of most of the cells of the stroma with the presence of moderate edema, and desquamation of the endothelium.

twelve to sixteen days, limbal blood vessels entered the cornea nearest the site of maximal damage. The tips of these vessels were often bulbous in shape. In milder burns, the corneal edema gradually subsided during the next few weeks leaving a thin opacity of granular consistency or with a silky sheen. More intense exposures produced ulceration of the cornea, occasionally some corneal infiltration, and in one instance a sequestrum-like area of tissue which sloughed (Fig. 11). Such corneas healed by dense white scarring and abundant vascularization.

Histologically, edema of the stroma and

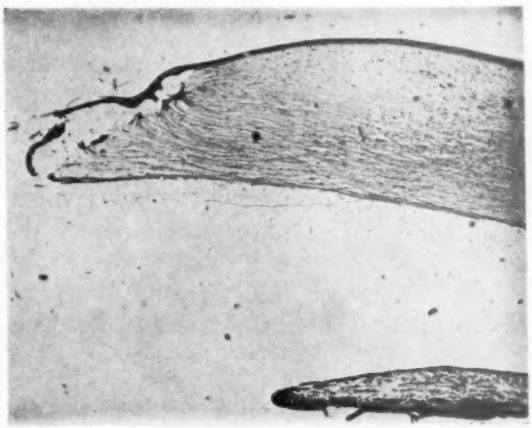

FIG. 13. Same section as in Figure 9, showing a central perforation of the cornea into which epithelium has grown. The zone immediately adjacent shows practically no cellular reaction.

disappearance of its cells were detected between two and ten days after exposure of 200 gram-seconds and 75 gram-seconds respectively (Fig. 12). A few mononuclear wandering cells were found in the burned area, but strikingly few polymorphonuclear cells. A moderate number of thin, darkly staining elongated cells could be seen at the peripheries of the lesion. The corneal endothelium disintegrated after exposure of this degree, and did not regenerate for two or three weeks. After fourteen to twenty-one days, blood vessels entered peripherally (Fig. 8) and profusely vascularized all layers of the cornea (Fig. 9). Ulceration and sloughing of the acellular stroma occurred

at times without much inflammatory reaction, resulting in perforation (Fig. 13). Sites of perforation were usually plugged by iris tissue and the proliferation of fibrous tissue.

Iris. The intensity of the iritis varied with the severity of the corneal lesion. The aqueous ray did not become positive until approximately forty-eight hours after a severe exposure. The iris frequently became congested and swollen within seven to ten days. On one occasion Koeppe nodules appeared, and occasionally a hypopyon developed. Residual scarring, atrophy, or depigmentation of the iris were infrequent. It would therefore seem reasonable to suspect that the reaction produced in the iris was secondary to the corneal involvement rather than a result of any direct necrotizing action of the irradiation.

Histologically, a little serum and a few inflammatory cells were ordinarily found in the anterior chamber a week or two after exposure. The iris vessels later became dilated, but cellular infiltration or evidence of necrosis in the iris were not encountered. Sections taken at six hours and twenty-four hours after exposure to 200 gram-seconds showed some mononuclear cells and a few polymorphonuclears in the posterior chamber, and the section at forty-eight hours revealed edema of the ciliary processes, but subsequent sections at three days and thereafter revealed no abnormality of the ciliary processes.

Lens. No evidence of lens damage was noted in any of the beta irradiation burns. The severe lesions, in which the corneas perforated, were followed about two months, and the eyes subjected to exposures of 12 gram-seconds every two weeks were followed for eight months.

DISCUSSION

1. *Changes in the Corneal Epithelium.* The histological changes in the corneal epithelium following exposure to beta irradiation illustrate several of the changes also described after exposure to roentgen rays or gamma rays in other epithelial structures. The basal layers of the corneal epithelium are affected most, the superficial stratified layers showing few alterations. This is probably related to the increased sensitivity of these basal cells which are the most immature and in which the mitotic activity of the corneal epithelium occurs. The initial histological changes after exposure to beta rays appears as a rarefaction and disorganization of the cytoplasm and outlines of the cell membranes. Later, many of the nuclei become swollen and the chromatin becomes clumped in small darkly staining masses, but the nuclear membrane temporarily remains intact. The rarefaction of cytoplasm and later swelling of cell nuclei because of edema has been repeatedly described after exposure to roentgen rays and gamma rays, and is considered by Failla[3] to be an important contributing factor in the destruction of the cell. Some of the peculiar formations of chromatin and binucleated cells after exposure to beta rays resemble abnormal mitoses. The nuclear fragmentation after beta irradiation is not unlike that seen after several other types of injury such as ultraviolet irradiation, mustard gas and the nitrogen-mustards.[4]

2. *Regeneration.* All layers of a beta-burned cornea show evidence of retarded regenerative processes when compared to that seen after injury by heat, cold, mechanical injury and chemical burns. It is possible that the persistence of the irregular and disorganized corneal epithelium obstructs the proper regeneration of epithelial cells which ordinarily slide over the surface of the damaged area. Relatively few new spindle-shaped cells appear at the periphery of the burned stroma, and the endothelium regenerates late. Vascularization appears somewhat later than for other lesions with equal corneal opacification. No evidence of any stimulating effect was found in these experiments.

3. *Depth of Beta Irradiation Effects.* Beta rays have a penetrability of about 1 cm. in tissue.[5] However, since only a small fraction of the total dose will penetrate this deeply, most of the rays are absorbed by the cornea

and aqueous before striking the lens. We observed no cataract formation after exposures as much as 200 gram-seconds unfiltrated or 300 gram-seconds partially filtered beta irradiation. For irradiation of low intensity, e.g., 6 gram-seconds, the pathologic effects are almost entirely limited to the epithelium, but the stromal cells and endothelium are readily affected by increasing the dose to 24–36 gram-seconds. The iris shows no effects of necrosis after severe beta-ray exposures, and the accompanying iritis is probably secondary to the corneal lesion.

4. *Possible Applications of this Information to Clinical Treatment.* Beta irradiation produces a localized destruction of tissue, delays processes of regeneration, and has no stimulating action. It should therefore be used with care for any corneal condition in which there has already been cellular destruction, because the effects might reasonably be expected to be additive in character, and to inhibit any regenerative processes which might be taking place.

The tissue reaction to be expected from a single exposure of beta rays varies greatly among different individuals, especially with techniques which do not accurately localize the area treated and maintain a constant distance of the applicator from the eye. The use of a contact glass applicator was designed to eliminate variations in the dosage applied to any localized area.

The depth at which beta irradiation effects are produced is somewhat dependent on the dosage, but the iris and lens are safe from ill effects even with doses which destroy the cornea.

SUMMARY AND CONCLUSIONS

The effects of beta irradiation from radon on the normal rabbit's eye are described. In addition to inherent differences in reactivity among individuals, variations in technique of application yield uncertain results. In order to control accurately the distance of the applicator from the eye and the site and size of the area treated, a contact glass holder for the beta applicator is described. Low doses of beta irradiation affect primarily the epithelium. Larger doses can affect all layers of the conjunctiva and cornea, but the iris and lens are not damaged. Strong exposures to beta rays are followed by a latent period free of clinical or histologic changes, the length of this period varying inversely with the dosage. Changes thereafter include: (1) disorganization of the corneal epithelium, especially loss of cytoplasm, variation in size and shape of the cells, and alterations in the chromatin; (2) loss of stromal cells; (3) desquamation of corneal endothelium with edema of the stroma, (4) relatively little inflammatory cell reaction, (5) secondary iritis, and (6) late regenerative changes. The cumulative effects of repeated doses of beta radiation is described.

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Vol. 56, No. 4

CANCER OF THE CERVIX

A STUDY OF THE EFFECT OF INTERSTITIAL RADON NEEDLES AS COMPARED WITH ROENTGEN THERAPY GIVEN THROUGH INTRAVAGINAL CONES

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THIS report is a preliminary survey of the comparative effects in the treatment of cancer of the cervix of radon needles introduced into the parametria and of roentgen therapy directed at the cervix and vaginal fornices through a small lead-lined cone. The study is based on 254 primary cases of cancer of the cervix treated at the Memorial Hospital during 1943 and 1944. On account of the short period of time that has elapsed, conventional five year cure rates are not available, but the two groups were so set up as to afford the basis for a satisfactory comparison. The results in the two groups have been so strikingly different that a brief account of them at this time seems warranted.

The work here to be reported represents a second effort to isolate and study in relation to end-results special factors in treatment. A previous report[5] analyzed the effects on the five year cure rate of different techniques of external roentgen therapy given in relation to a constant method of radium application to the uterus. The two methods compared consisted in the so-called "*massive dose technique*" of pelvic roentgen therapy, i.e., 750 r at a single treatment to each of four pelvic fields, 50 cm. target-skin distance, 200 kv., 0.5 mm. copper filtration and the "*divided dose technique*," i.e., twelve treatments of 200 r each to each of six fields, 70 cm. target skin distance, 200 kv., 0.5 mm. copper filtration. With each type of external roentgen therapy, radium application was made by means of two radium capsules within the cervix, delivering 3,000 millicurie-hours and by a vaginal applicator or "bomb," delivering 1,500 mc-hr.

During the years 1932 to 1937 there were treated 920 cases of cancer of the cervix at the Memorial Hospital. Three hundred and eighty-seven cases were considered suitable for studying the relative merits of the two methods of treatment. Analysis showed that among 288 cases receiving the "divided dose technique" there were five year cures in 35.4 per cent; in the 99 receiving "massive dosage," there were 28.5 per cent. Similarly for three year cures, the "divided dose" yielded 36.1 per cent in 163 cases, the "massive dose" 30.2 per cent in 363 cases.

A careful study of this material indicated that these differences were not due to a selection of unfavorable cases for the "massive dose" type of treatment. Rather did corrections for extent of disease, age of patient, and pathological grade tend to emphasize the superiority of "divided dose technique." With this study as a base, it has been the policy of the gynecological service since January, 1943, to treat all patients with some form of "divided dose technique" as far as external pelvic roentgen therapy is concerned.

The next step seemed to be the search for the best method of application of radiation internally to cervix and parametria.

When this study was commenced, the usefulness of the vaginal radium applicator—the so-called "bomb"—was immediately questioned by the physics department of the Hospital. It was pointed out that because the radium in this applicator was placed almost in contact with the cervix, the dosage received by tissues below the surface of the tumor must be very low. The radiation reaching the parametria more than 2 cm. from the cervix was largely contributed by the external roentgen ther-

apy. The effect of the bomb in the lateral fornices or on the upper portions of the cardinal ligaments was almost negligible.

A perusal of the literature suggested two contrasting methods of treatment which might replace the vaginal bomb and greatly increase the radiation delivered to the parametria. The first of these was the use of interstitial radium by radon needles introduced directly into the parametria through the vaginal vault. This method was not a new one, but clinical reports by Teahan, Wammock and Weatherwax,[13] by Arneson and Hauptman,[2] and especially by Pitts and Waterman[10,11] had been very optimistic. Indeed the last authors reported a five year survival rate of 36 per cent in a series of 264 patients, about the highest survival rate for any large series of cervical cancer reported in this country. Recently Waterman and Di Leone[15] have reported a 39.3 per cent five year cure rate in 127 cases treated in 1936 to 1938.

The second method, as a possible improvement on the radium "bomb," was roentgen therapy given through a cone or cylinder introduced into the vagina. This also is an old method, having been suggested by Allen[1] as long ago as 1904. Merritt[8] had given treatments to the cervix exposed by special Ferguson specula equipped with obturators for introduction and shields at the skin surface. Erskine[4] had developed a series of ingenious expanding specula for treatment at short target skin distances, the purpose being to include both parametria in a single beam. More recently Wasson[14] has described the use of a series of cylinders made of brass to be attached to a low voltage shock-proof machine and to be aimed at different areas in the upper end of the vagina. In Germany, Martius and Witte[7] have worked for many years on various forms of intravaginal roentgen tubes. The results of their use of the most satisfactory model have been described by Martius,[6] who finds an increase in total five year cures for "Group III and IV" cases from 23.5 per cent to 33.3 per cent by this method.

CASE MATERIAL

One technique of irradiation cannot be satisfactorily compared with another, when these methods are applied in different clinics because of differences in the character of the original case material. Even within a single clinic a dependable conclusion cannot be reached by comparing the results obtained by one method in one period of years with those obtained by another method in subsequent years, because of the probable effects of educational campaigns in bringing earlier cases.

It is almost essential that both methods for study be employed simultaneously and in the same clinic, the cases as they apply for treatment being carefully and fairly assigned to one or the other method.

To show that classification of cancer of the cervix according to the extent of the disease is not an exact procedure but depends greatly on the judgment and attitude of the examiner, the distribution of cases to various stages during the years of this study and in the cases of the 1932–1937 series[5] may be cited. In the earlier series it was found that 15.9 per cent were Stage I, 32.9 per cent Stage II, 45.7 per cent Stage III, and 1.8 per cent Stage IV. In the present group, 20.3 per cent were classified as Stage I, 45 per cent Stage II, 28.3 per cent Stage III, and 6.4 per cent Stage IV. The difference may be attributable in part to an actual improvement in case material, but certainly also to a partial change in the staff examining these patients.

To obtain groups as nearly comparable as possible, the following procedure was adopted. All cases of cancer of the cervix were examined as they came to our clinic by one of the two of us. The cases were classified according to the League of Nations classification as modified in 1937,[3] which may be simply stated as follows:

Stage I included all cases in which the tumor was confined to the cervix.

Stage II included those cases with parametrial or upper vaginal involvement, but no fixation.

Stage III consisted of the cases with fixation of the parametria on one or both sides, or with

involvement of the lower vagina. This stage included some cases with "frozen pelves."

Stage IV contained the cases with metastatic disease outside the true pelvis or actual invasion of the bladder or rectal mucosa by tumor.

After examination, a diagram of the examiner's concept of the extent of the disease was drawn and the stage of the disease decided. The case was then placed, without the knowledge of the examiner, either in Group A to be treated by intravaginal cones or Group B to be treated by radon parametrial needles. In each stage the cases were alternately put into Group A or B.

Both of the methods were, on physical grounds at the beginning of the work, considered to be superior to the original radium bomb. The alternation was considered justifiable since in the beginning there was no ground for considering the vaginal cones or the needles superior. Toward the end of the second year when definite differences became evident, the apparently inferior method was dropped and the study terminated.

During these two years 254 cases had been so assigned in alternation to the two forms of therapy. The groups were not, however, of exactly equal size. When the study ended, there was one more case in Group A than in Group B in each stage. Furthermore, 2 of the cancers of the cervical stump in Group B had been treated with vaginal cones instead of needles because of concern over anatomical relationships after hysterectomy. Thus there were 131 cases in Group A and 123 in Group B.

From these original groups, other subtractions had to be made. One case in Group A and 3 cases in Group B never returned to the hospital for treatment after their initial visit. Twelve cases in each group had roentgen therapy, but never had any application of radium. One case in Group A and 2 in Group B were proved later to have primary adenocarcinoma of the corpus, and were transferred to that classification. Four Group A cases, on account of the local anatomy of the lesion, were treated by the insertion of parametrial needles. Twelve cases who were scheduled to have parametrial needles inserted never had this done. Eight of these were near the end of our series when we had become convinced of the high degree of morbidity induced by needles and were, in consequence, somewhat loath to use them.

If, then, we count only those cases of cancer of the cervix which received external divided dose roentgen therapy and some form of intracervical radium, we find that 113 cases were treated with intravaginal cones and 94 by the insertion of parametrial needles (see Table 1).

TABLE I

	Group A	Group B
No treatment at Memorial Hospital	1	3
No radium used	12	12
Later diagnosis adenocarcinoma of the corpus	1	2
Group A cases treated with needles	4	—
Group B cases treated without needles	—	12
	18	29
Suitable cases	113	94
	131	123

IRRADIATION TECHNIQUES

The patients in Group A were treated by divided dose external roentgen therapy and through the vaginal cones pictures in Figure 1. These cones were made of brass and lined with lead and fitted into a master cone attached to the 120 kv. low voltage therapy machine, which was completely shock-proof. The distance from the target to the end of the cone was 35 cm. The filtration was 3 mm. aluminum. Accurate direction of the roentgen-ray beam was secured only after considerable experience. With the patient's legs in stirrups, the cone was inserted by means of an obturator which closed its vaginal end. The obturator was then removed and the field of irradiation

observed by looking through the cone with suitable illumination. The machine was then lowered into position to engage the end of the cone without changing its position.

one directly to the cervix and one to each vaginal vault, were usually possible. Typically, the cervix received four treatments of 500 r at a treatment (measured in air) for a total dose of 2,000 r. The parametrial

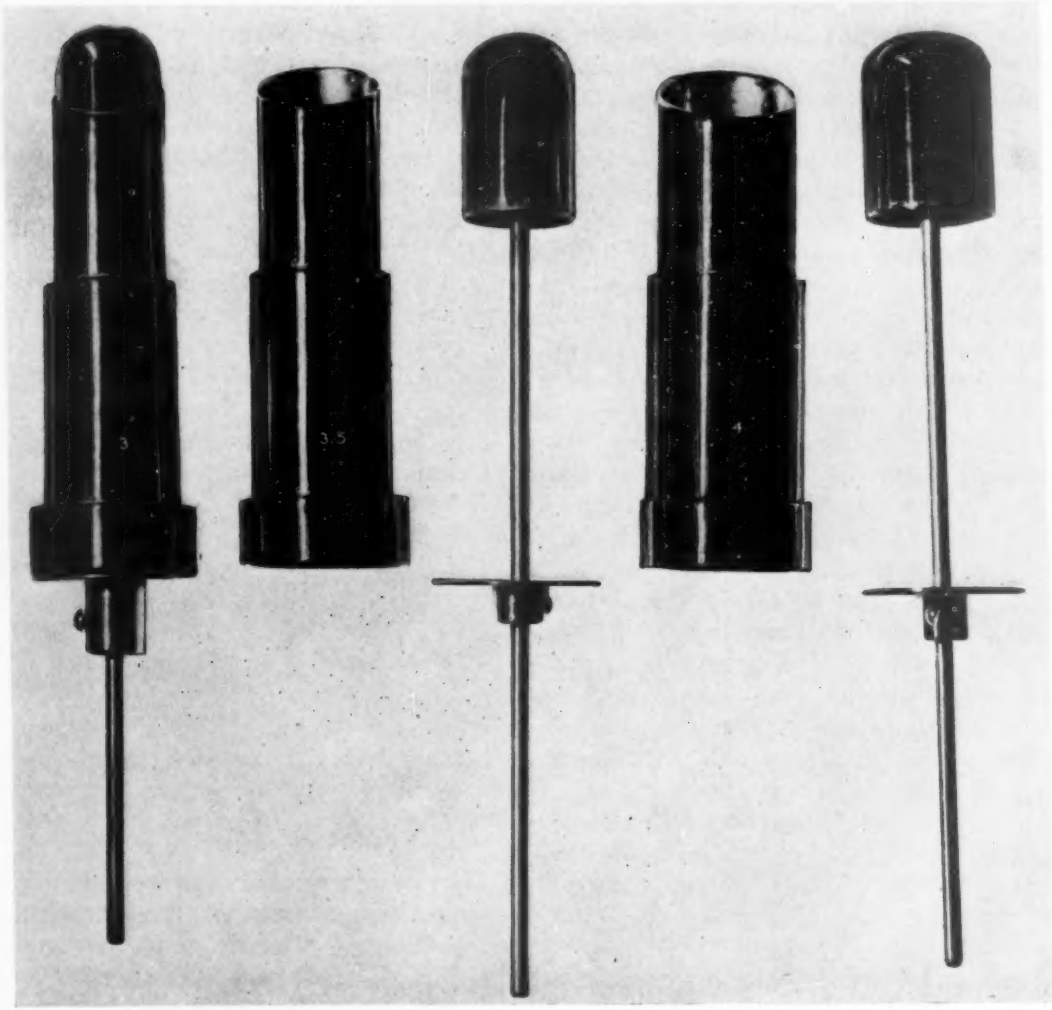

Fig. 1. Three sizes of intravaginal cones used in treating cancer of the cervix. These cones fit a master cone on the 120 kv. shock-proof roentgen therapy machine. The obturators used in introducing the cones are shown alongside of them, except with the 3 cm. size, into which the obturator has been inserted.

In the typical plan of irradiation, the intravaginal therapy was given three times a week during the course of external roentgen irradiation and before the application of radium to the cervix. With the 3 or 4 cm. cone, three fields of vaginal irradiation,

treatments of 750 r each were given through a 3 cm. cone pointed into each vault. For this purpose the cone was directed at an angle of 30 degrees from the long axis of the body, an attempt being made to get the end of the cone into the fornix lateral to

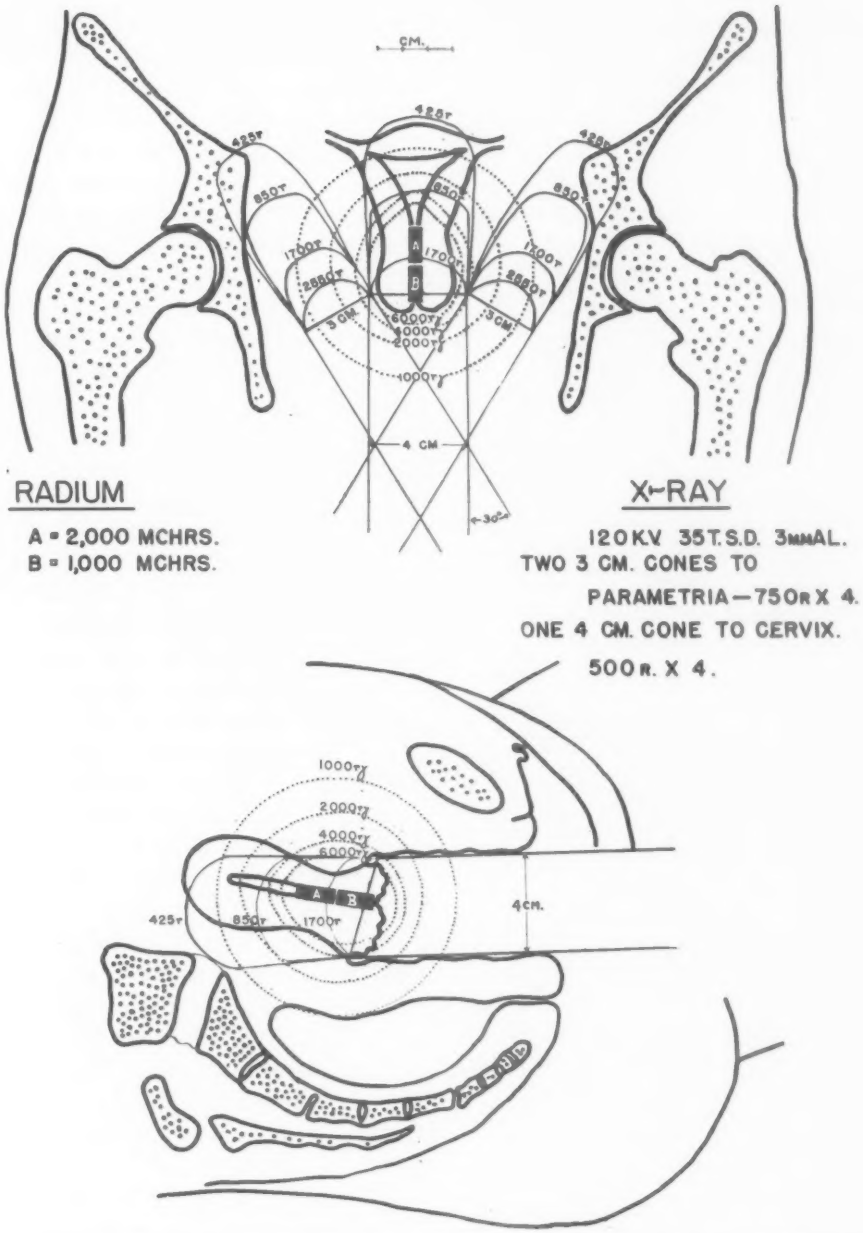

Fig. 2. Diagrammatic representation of the method of treatment and dosage used for treatment of cancer of the cervix with intravaginal cones. The dotted lines show tissue gamma roentgens (r_γ) delivered by the intracervical radium. One thousand gamma roentgens are approximately equal to 1 threshold erythema dose. The solid isodose lines show doses delivered by the intravaginal cones. Four hundred twenty-five roentgens is approximately 1 threshold erythema dose.

the cervix. Each fornix was treated four times, giving a total dose of 3,000 r (Fig. 2).

It was found very shortly that patients who were receiving intravaginal cone treatments were developing rather severe rectal symptoms, diarrhea, tenesmus and pain. These symptoms did not occur in such troublesome fashion when care was taken to have the vaginal cone almost horizontal so that it pointed to the promontory of the

sacrum or even anterior to it, rather than in the normal axis of the vagina. A small pillow under the patient's buttocks helped to straighten the direction of the vaginal canal. The patients were instructed to empty the bowel every morning before they came to the hospital for treatment, using a glycerine suppository if necessary.

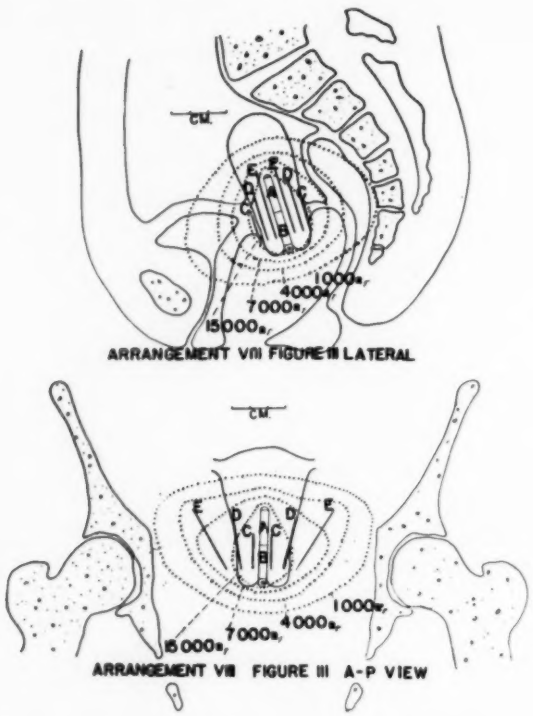

Fig. 3. Arrangement of radium capsules and parametrial needles used in this investigation. Dotted lines show tissue gamma roentgens, 1,000 r_γ being approximately 1 threshold erythema dose. (Reproduced by permission from Nolan and Quimby,[9] *Radiology*, 1943, *40*, 391–402.)

This description is obviously that of an ideal treatment. Some women had narrow vaginas and had to receive all their treatments through a small cone. In some cases the vault of the vagina was narrow and the fields of necessity overlapped. In some cases it was hard to angle the cone laterally as much as was desirable. Frequently the cone was adjusted to treat an area of carcinomatous extension which could be easily palpated. On account of difficulties in making appointments for the one machine available, some patients had to have the intravaginal treatments after the rest of the external roentgen therapy had been finished.

Two weeks after completion of all roentgen therapy the patient was admitted to the hospital and a radium applicator was inserted into the cervical canal under pentothal anesthesia, for a dose of 3,000 mc-hr.

The patients in Group B who were to receive parametrial radon needles started their therapy with external roentgen irradiation, receiving ten treatments of 200 r each to each of six pelvic fields with the 200 kv. or 250 kv. machine. Two weeks after the last treatment they were admitted to the hospital for radium. The radium application was made according to the plan outlined by Nolan and Quimby,[9] who had carried out a special study of the distribution of radiation from various combinations of needles and tandems in the physics department of the Hospital just before our present study was begun. Their plan was a slight modification of that used by Pitts and Waterman. The principal change was the use of a two capsule tandem, with the lower capsule twice as strong as the upper one, in place of their 4 cm. cervical applicator of uniform strength. They also recommended that the four needles inserted into the cervical tissue be 2 cm. in active length rather than 3 cm.

The actual procedure began with the exposure of the cervic with suitable retractors and a slight dilation of the cervical canal. Four steel sheath needles containing radon gas in gold tubes 2 cm. in active length were then inserted into the periphery of the cervix, two in front and two in back, the needles of each pair being separated from each other by about 1 cm. Lateral to each of the first needles and separated from it by about 1 cm. was placed another needle, four in all, having an active length of 3 cm. These were angled out slightly toward the parametria. Finally four needles of 4 cm. active length were inserted, two into each side, at a distance from each other and the neighboring 3 cm. needles of about 1 cm.

and directed into the parametrium at an angle of about 30 degrees. This arrangement is illustrated by Nolan and Quimby's diagram (Fig. 3).

After the needles had been inserted, a radon tandem approximately the length of the cervical canal and containing about the same amount of radon as was present in all the needles combined was slipped between the vaginal ends of the needles into the canal, and it and the needles packed in carefully with long strips of 2 inch gauze packing. This packing was used not only to keep the needles and tandem in place, but to distend the vagina and keep the rectum and bladder base as far away as possible from the radium. The patient's bladder was kept empty by an indwelling catheter.

The radium was left in place until a total dose of 6,000 mc-hr., approximately 3,000 from the needles and 3,000 from the tandem, had been delivered. Since radon was used, the strength of the applicators varied. In general, the needles altogether averaged about 100 mc. in strength, with the cervical tandem amounting to another 100 mc. Some needles, however, were as weak as 60 mc. and some as strong as 212 mc. Thus the time of treatment varied from twelve to fifty hours, the average being about thirty hours.

RESULTS

This report is not based on the usually accepted five year follow-up, and is, therefore, in one sense a progress report of an experiment already done, but whose final results are not yet complete. The patients whom we are reporting were first seen and their treatment begun in the years 1943–1944. Follow-up data are available on these cases for periods ranging from nine to thirty-four months, the average being 19.6 months. However, since the patients were so carefully alternated between our two groups, the data we are able to present now have considerable significance in contrasting the value of these two particular techniques.

TABLE II

	Group A						Group B					
	Stage I	Stage II	Stage III	Stage IV	Cervical Stump	Totals	Stage I	Stage II	Stage III	Stage IV	Cervical Stump	Totals
Alive without disease	20	23	4	0	7	54	10	14	1	0	1	26
Alive with cancer	2	3	3	0	1	9	0	6	0	0	1	7
Alive with ? cancer	0	3	1	0	0	4	1	1	1	0	1	4
Dead with cancer	2	9	17	5	2	35	4	16	14	1	4	39
Dead without cancer	0	1	0	0	0	1	1	0	0	0	0	1
Dead with ? cancer	0	2	0	0	1	3	1	5	3	1	2	12
Lost	0	2	4	0	1	7	2	3	0	0	0	5
Total	24	43	29	5	12	113	19	45	19	2	9	94

Of 113 cases in Group A treated with vaginal cones, 54, or 47.8 per cent, were alive and free of cancer when last examined before the statistics were compiled. Of the 94 cases in Group B treated with parametrial needles, 26, or 27.7 per cent, were alive and free of cancer. In Group A, 39 were dead, or 34.5 per cent. In Group B, 52, or 53.3 per cent. In Group A, 67 were alive, 9 with cancer and 4 possibly with cancer, or 59.3 per cent; in Group B, 37 were alive, 7 with cancer and 4 possibly with cancer, 39.4 per cent.

Not only was the total number of pa-

tients alive or alive without evidence of cancer greater in the group treated with cones, but this was uniformly true in all stages of the disease (see Table II). In particular it was interesting to note that in Stages II and III, where the parametria were involved with cancer, the results with needles were inferior.

In addition to the higher expectancy of life, the group treated by vaginal cones enjoyed the advantage of fewer complications of treatment. The complications occurring with each form of therapy are listed in Table III.

TABLE III

MORBIDITY—COMPLICATIONS

	Group A (Cones)	Group B (Needles)
Diarrhea	10	33
Rectal bleeding	11	24
Rectal stricture	7	18
Rectal fistula	5	12
Local necrosis (cervix or vaginal vault)	50	63
Vaginal hemorrhage	17	27
Genitourinary symptoms	23	33
Pain (excessive or noted on chart)	51	63

Perhaps the most marked contrast is to be found in the occurrence of rectal symptoms. Among the patients treated with interstitial needles, 33 complained of troublesome diarrhea, 24 of rectal bleeding, 18 developed rectal strictures and 12 fistulas. Of these last, 9 were patients classified as Stages I and II; in other words, the fistula was due to irradiation injury of the rectal wall and not to destruction of cancerous tissue which had already invaded the rectum. In the cases treated with vaginal cones, only 10 complained of diarrhea, 11 of bleeding, 7 developed strictures and 5 fistulas. Three of these latter were in advanced cases, Stages III and IV.

Perhaps the explanation of the more frequent rectal symptoms in patients treated with needles is to be found in the difficulty of determining the position of the parametria from vaginal examination. A private patient, not one of the present series, was operated upon for the purpose of removing the pelvic lymph nodes, as advocated by Taussig,[12] immediately after the insertion of the parametrial needles. Figure 4 shows the posterior cul-de-sac as seen through the laparotomy wound, with substantial portions of each of five of the needles easily visible. In addition, the two 3 cm. needles on the left side could be seen and felt but do not show in the photograph. The second 4 cm. needle on the left lay between the uterine artery and the ureter. It seems probable that needles, 3 or 4 cm. in length, placed according to the technique described, will often pierce the thin bases of the uninvolved broad ligaments and so come to lie alongside the rectal wall.

The criticism might be made that the needles were inserted too much toward the rectum, but the frequency of bladder symptoms seems to preclude any shift in an anterior direction. Thirty-three of the cases treated with needles complained of severe symptoms of bladder irritation. Five cases in Stage I and Stage II developed vesicovaginal fistulas, while none of the cases of these stages treated with vaginal cones did so. Twenty-three of the cone-treated patients did, however, complain of some symptoms of bladder irritation.

Necrosis of the tumor, cervix and vaginal vault are a striking feature in the charts of the cases treated by needles. In 63 of the 94 histories, this necrosis is mentioned specifically. Vaginal hemorrhage occurred in twenty-seven.

In the other group, the patients treated by cones, 50 of the 113 patients showed some local necrosis, but this was usually not so deep or extensive as in the needle cases. Seventeen patients of the cone group experienced vaginal hemorrhage.

DISCUSSION

A brief consideration may be given to possible reasons for the more favorable results obtained by other workers with the use of interstitial radium in cancer of the cervix. From illustrations published by

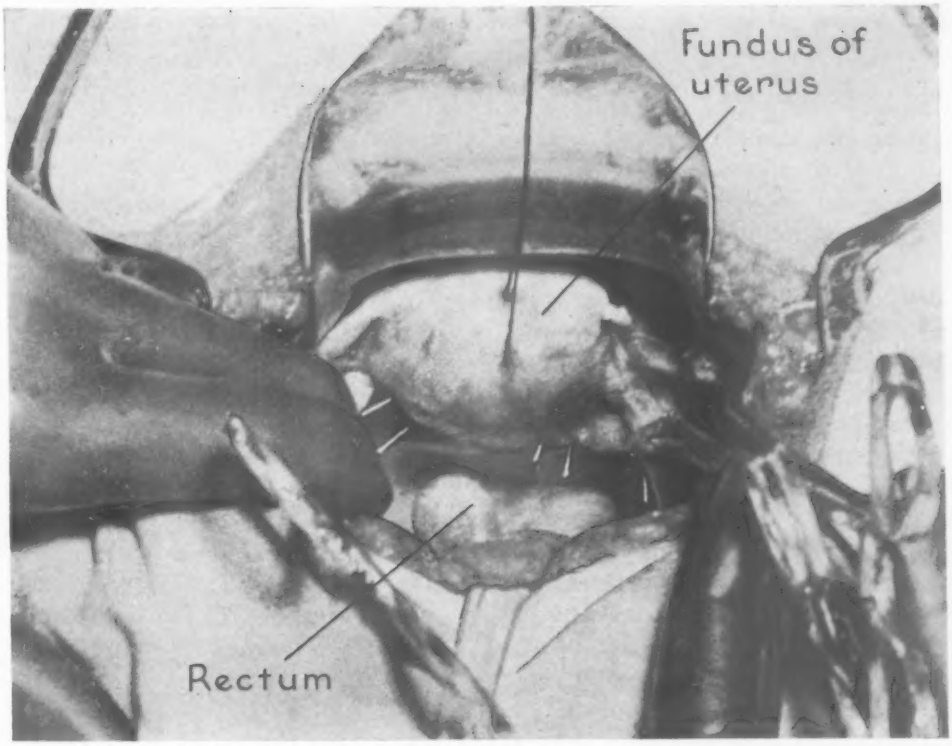

Fig. 4. This photograph was taken during a laparotomy on a patient into whose cervix needles had been inserted, as described in the text. The ends of five parametrial needles projecting into the posterior cul-de-sac are easily seen. Were the fundus of the uterus not pulled forward by a suture, it is readily understood that these needles would lie in close apposition to the anterior rectal wall.

Pitts and Waterman,[10] it appears that they tended to keep the needles in closer to the corpus of the uterus than we did. Their needles have a wall thickness of 0.5 mm. of platinum, while we were using steel needles with radon-filled gold tubes inside them with a wall thickness of 0.3 mm. Pitts and Waterman left their needles in place for 168 hours, while in our cases the intensity was greater and the time consequently shorter, fifteen to fifty hours. Thus differences in results might be due to many factors; namely, to the distribution of radium, the filtration, the intensity of radiation, or the experience of the surgical personnel. That the method is not without complications even in the hands of Pitts and Waterman is shown by a reported incidence of 38 fistulas in 480 cases, or 7.9 per cent. Our cone-treated cases showed 7 fistulas in 113 cases, or 6.1 per cent.

It is not intended to advocate the use of vaginal cones as superior to any other method of irradiation in cancer of the cervix. These cases have been followed for much too short a time for us to have any opinion as to whether the ultimate cure rate will be better than it has been with the past technique employed by the Hospital which was based on the divided dose roentgen therapy, vaginal radon bomb, and cervical tandem. By *a priori* reasoning, the use of cones would be expected to give good results, for they deliver uniform radiation in fairly large doses into the parametria at a depth from the vagina more successfully than any other method.

This paper is simply a progress report describing preliminary results obtained by treating comparable groups of cases by two methods thought at the start to be equally effective. In our experience, using our particular radon needles, parametrial interstitial irradiation has proved to be more dangerous to the patient and not so effective in curing the cervical cancer as the

treatment of the parametria with vaginal cones.

SUMMARY

1. During the years 1943 and 1944 all primary cases of cancer of the cervix coming to the gynecological clinic of the Memorial Hospital were divided into two equal and comparable groups.

2. One group was treated with divided dose roentgen therapy to the pelvis and intravaginal roentgen therapy to the parametria and cervix through special cones. This program of roentgen therapy was followed by intracervical radium. The second group also received divided dose external roentgen therapy and intracervical radium, but the intravaginal roentgen treatments were replaced by interstitial radon therapy delivered by means of needles inserted into the parametria at the time the radium was applied to the cervical canal.

3. At the present time, from nine to thirty-four months after treatment was begun, 54 of 113 cases (or 48 per cent) treated with intravaginal cones are alive and apparently free of cancer; 39 (or 34.5 per cent) are dead. Twenty-six of 94 cases (or 28 per cent) treated with interstitial needles are alive and apparently free of cancer; 52 (or 53 per cent) are dead.

4. The patients treated with needles had more severe rectal symptoms (diarrhea, bleeding, stricture and fistula), more bladder symptoms (dysuria, frequency, hematuria and fistula), and more local necrosis, hemorrhage and pain than did those treated with vaginal cones.

5. We have concluded that *in our experience* the use of interstitial radon needles is relatively ineffective and dangerous as a method of controlling cervical cancer and we have abandoned it in favor of intravaginal and external roentgen therapy combined with intracervical radium. The final results of this type of treatment are, however, not yet known.

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TREATMENT OF CUTANEOUS HEMANGIOMA WITH RADIUM*

By EDUARDO CACERES, M.D.

LIMA, PERU

BY THE term hemangioma we mean vascular, congenital tumors occurring in the skin, subcutaneous tissues, or other structures. They form the most frequent group of tumors occurring in childhood.

MacKee[2] divides hemangiomas of the skin into capillary and cavernous types.

The capillary hemangioma is divided into (*a*) the nevus flammeus or simple variety (port wine mark), composed of a network of small capillaries without marked cellular proliferation; and (*b*) the nevus vasculosus (strawberry mark), a more active growth which produces upon the skin soft, elevated nodules.

The cavernous hemangioma is composed of blood spaces lined by a single layer of endothelium and filled with blood or serum. However, it is not uncommon to find, especially on the face or scalp, a cavernous hemangioma in which the overlying skin is the site of a nevus vasculosus.

Hemangioma should be treated in such a manner that there is an entire disappearance of the lesion without visible scar, atrophy or telangiectasis of the skin.

In spite of the fact that hemangioma is often self-limited and may even regress spontaneously, persistent, untreated lesions in adults and rapidly spreading lesions in infants occur frequently and justify treatment as early as possible. Hemangioma is usually present at birth but in a certain number of cases may appear several days or even as late as three weeks after birth.

Generally hemangioma increases in size during infancy. The rate of growth varies, some enlarging very rapidly and others growing slowly. Growth is usually arrested by the first radium treatment. The best results are obtained with small lesions. The radiosensitivity is greatest in early infancy, when the endothelial cells lining the blood spaces still retain their embryonic character. Therefore, treatment early in life gives the better cosmetic result. The scar and pigmentation which occur in some cases diminish with the years. If treatment has been given during infancy, sufficient time will have elapsed for the scar to become inconspicuous by the time a child reaches an age when he may become conscious of a physical defect. The psychological effect of a physical defect upon a child must not be ignored.

Therefore, radium treatment should be given preferably during the first six months of life. A rapidly growing hemangioma must be treated immediately, even during the first weeks of life. Ulceration of the hemangioma is no contraindication to radium treatment but scarring will result when the ulceration heals.

Hemangioma may be treated by one or more of the following methods: carbon dioxide snow, electrocautery, injection of sclerosing fluid, excision or some form of irradiation. Because of very satisfactory results in the treatment of cutaneous hemangioma with radium, and since this method is simple, the discussion of the technique of treatment and dosage will be limited to the various types of external radium applications: (1) filtered contact radium and (2) filtered radium at distance (mold, plaque).

Radium Applicators. For filtered contact radium, platinum tubes containing 10 mg. of radium element are used. For filtered

* From the Chicago Tumor Institute, Chicago, Illinois. Read at the second Mexican National Congress of Cancer, Guadalajara, Mexico, Feb. 3–9, 1946.

radium at distance there are two types of radium applicators generally used at the Chicago Tumor Institute: plaque and mold.

There are three different sized radium plaques to simplify the treatment of different sized lesions. The filtration of these plaques is the equivalent of 3.8 mm. of brass. The radium skin distance is 5 mm. Small blocks of cork are used to maintain this distance. For complete protection the applicator is surrounded with a 2 mm. thick lead box. Radium tubes containing 10 or 25 mg. of radium element are employed. The amount of radium required determines the number of tubes used. Generally it is about 100 to 150 mg.

Radium mold: the material used for this purpose is dental molding compound or Columbia paste, which is made in various thicknesses, usually 5 mm. and 7 mm.

The radium mold is charged with tubes of 10 mg. of radium element filtered by 1

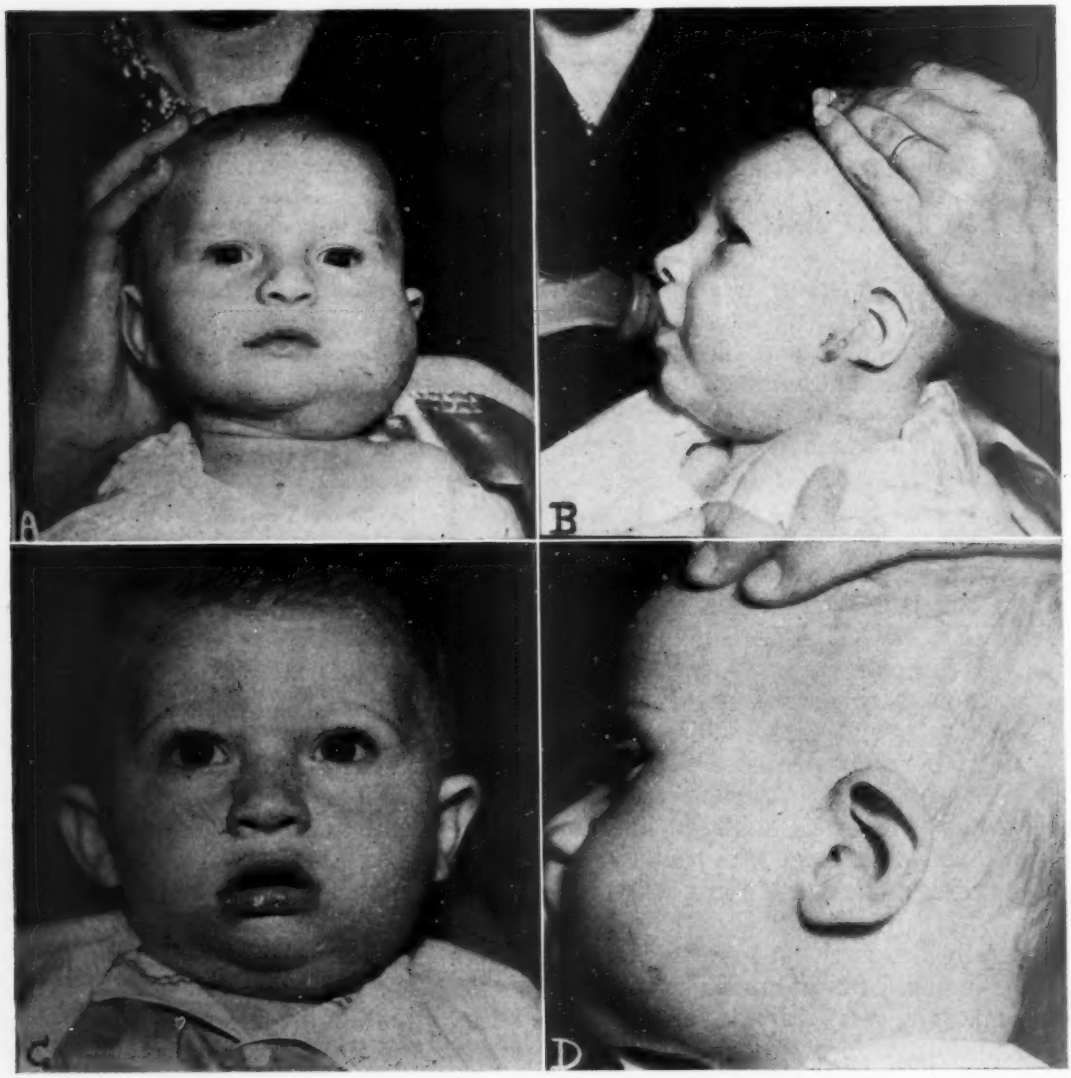

Fig. 1. *A*, large cavernous hemangioma in left cheek. *B*, strawberry mark on left pre-auricular area. *C* and *D*, cosmetic restoration seven months after treatment. Lesion was treated by radium plaque, two fields, 1,250 mg-hr. each.

Fig. 2. *A*, cavernous hemangioma in the upper lip. *B*, results ten months after treatment. Lesion was treated by radium plaque 880 mg-hr.

mm. of platinum. It is evident that the distribution of the radium over the surface of the mold constitutes an important problem. Although it is impossible, from a practical point, to make the radiation uniform, the proper distribution can reduce the variation to a maximum of 10 per cent. The tubes, in either single or double rows, should not be equally spaced because the center would receive the greatest intensity. They should be placed closer together toward the ends of the row and farther apart in the center. In large lesions, the radium is arranged around the periphery. The number of individual problems occurring with this subject are innumerable and cannot be included in a report such as this. A complete discussion of this subject is given by Quimby.[3]

Selection of the Treatment. Most authors[1,2,4] are in agreement that the simple nevus is not a suitable subject for radium or most other forms of therapy. Surgical excision is a satisfactory method for some lesions. Cosmetics may be used to cover the "port wine mark."

The "strawberry" hemangioma responds very well to radium therapy. The lesions which are localized in the superficial layer of the dermis are best treated by contact radium therapy. A cavernous hemangioma situated in the subcutaneous tissues requires more penetrating radiation because of its greater bulk. Very large cavernous hemangiomas may require a combination of external and interstitial irradiation (removable radium needles). The necessity of using interstitial irradiation will depend upon the response to external irradiation.

The combined lesions "cavernous" and "strawberry" which frequently occur may be treated first by radium plaque. If, after the cavernous part of the hemangioma has responded, areas of skin discoloration still persist, contact radium therapy may then be used.

Very small pink lesions of the face should be treated by beta radiation. When the lesion is in a difficult position for a good application of a plaque or when the surface area of the lesion is greater than the area of standard applicators, mold applicators are used. Very extensive hemangiomas may be divided into several fields and

the various areas treated at intervals of one week. A margin of 3 or 4 mm. must be left between the treatment fields to avoid overlapping or excessive reaction.

Technique of Application. 1. Contact radium therapy: the radium tubes are fixed by cellulose adhesive tape, a transparent material which permits complete visualization of the lesion and the radium tube.

2. Molds generally are fixed to the skin by adhesive tape but may be fastened by tapes through small holes in the mold.

3. The plaques are fixed by adhesive tape or bandages. Great care must be given to the adjustment of the applicator so that it does not slip. The size of the applicator must be 3 to 4 mm. greater than the lesion. If the hemangioma is prominent, slight compression with the applicator is advantageous. During the course of irradiation the positioning should be checked frequently.

Dosage. In the United States the dosage is generally expressed in terms of milligram-hours or millicurie-hours. It is computed by multiplying the number of milligrams of radium or millicuries of radium emanation utilized, by duration in hours of

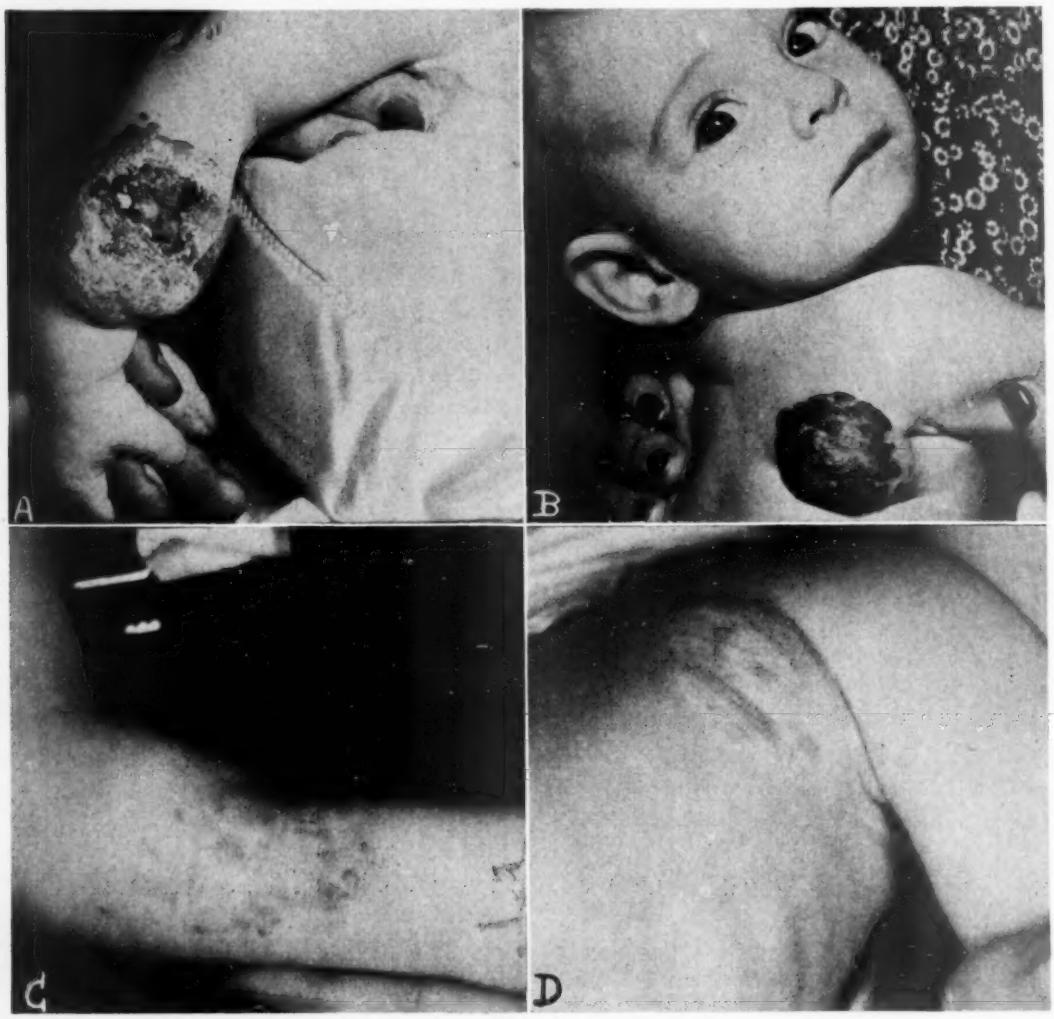

Fig. 3. *A*, ulcerated cavernous hemangioma of the right forearm. *B*, large cavernous hemangioma of the right scapular area. *C* and *D*, condition two and a half years after treatment by radium plaque, two fields, 800 mg-hr. each.

FIG. 4. *A*, cavernous hemangioma of the left eyelid, forehead and temporal region. *B*, result two years and nine months after treatment. Radium plaque, two fields, 620 mg-hr. each.

the application. When unfiltered radium is used, the dose is measured by milligram-minutes. Elsewhere the French measurements are followed; this is computed by the quantity of radium destroyed during the course of application. The advantage of this method is that the same measuring factor is applicable to tubes of radium or of radon. One millicurie-destroyed is the equivalent of 133 milligram-hours or of 133 millicurie-hours. One milligram-hour is equivalent to 7.55 microcuries-destroyed. Either of the methods fails to consider the energy produced and measures only the source of the radiation like measurement of roentgen rays in kilovolt-hours and milliampere-minutes. Radium dose expressed in roentgens is probably the most accurate.

When determining the dose to be used, the minimal quantity of radiation which appears to affect the vascular tumor should be employed. The dose should be low enough to avoid skin reaction.

Since the sensitivity of the skin varies with age, location and condition, dosage is a matter of experience and it is not possible to make rigid standards. The dosage will depend on many factors: distance from the skin surface of the area treated, strength of the applicator, and the character of radiation (beta or gamma). In the treatment of hemangioma the single dose is more important than the total dose. The suberythema dose should never be exceeded. The total dose is determined by the response of the hemangioma to the treatment.

In the series treated with radium plaque in all the cases but one the individual total dose for a single field did not exceed 800 mg-hr. The single dose usually was 100 mg-hr.

In contact radium therapy 10 mg. tubes of radium are employed, the size of the lesion determining the number of tubes. For small lesions, where one or two tubes are sufficient to cover the lesion, 10 to 20 mg-hr. is the usual single dose. Where 3, 4 or 5 tubes are used, a single dose of 25 to 40 mg-hr. must not be exceeded. The total dose in the series was between 120 and 185 mg-hr.

For beta radiation therapy, a 25 mg. radium tube, filtered by 0.2 mm. of monel, is used. A dose of 75 to 100 milligram-minutes is not exceeded.

Intervals Between Treatments. The special

sensitivity of children's tissues should enter into consideration when determining the interval between treatments. These should be spaced to avoid injurious accumulation. Routinely treatments are given every three or four weeks although in certain cases they can be given every week. If there has been intense erythema the next treatment should be delayed for two weeks or until the reaction has subsided. Usually after three or four treatments, if the lesion has regressed sufficiently, the interval should be increased to two or three months. This may avoid overtreatment.

ANALYSIS AND RESULTS

The following is an analysis of the results in 66 cases of hemangioma treated in the Chicago Tumor Institute:

Sixty-nine per cent of our cases were referred for treatment during the first year of life. In 7 cases the treatment was given before two months of age. The ratio between females and males is 2 to 1. In 46 per cent the lesions were found on the head and neck. Twenty-nine per cent had multiple hemangiomas. Several children had as many as four lesions.

In evaluating the results of treatment, we have considered as "excellent" those where the site of the hemangioma cannot be detected, and those in which the results have not been so perfect but the size and state of the covering skin permit us to consider it as such; as "satisfactory" those where some discoloration or scarring remained; as "failure" those which did not respond sufficiently to be included in the other groups.

Of the 66 unselected cases of hemangioma treated at the Chicago Tumor Institute 49 (74 per cent) may be classified as excellent, 13 (20 per cent) as satisfactory and 4 (6 per cent) as failures.

SUMMARY

Radium treatment of cutaneous hemangioma is discussed, selection of treatment, dosage and the technique of radium therapy being presented in detail. Statistics regarding age, sex, distribution and end results are reported.

I am indebted to Dr. Esther Marting for her helpful comments during the development of this paper.

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Representatives on American Board of Radiology: Douglas Quick, New York, N. Y., B. P. Widmann, Philadelphia, Pa., F. W. O'Brien, Boston, Mass.

Committee on Arrangements: To be appointed.

Twenty-ninth Annual Meeting, 1947: To be announced.

EDITORIALS

THE ANNUAL MEETING

THE Forty-seventh Annual Meeting of the American Roentgen Ray Society which was held at the Netherland Plaza in Cincinnati, Ohio, September 17 to 20, 1946, was marvelously well attended, there being over a thousand people in attendance. The mere presence of numbers, however, does not in itself indicate the quality of the meeting, but the enthusiasm of the members of the Society and their guests for the scientific program was evidenced by the attendance at the scientific sessions, and President Beeler and his committee may be congratulated upon the versatile and comprehensive program which was arranged. This being the first post-war meeting of the Society added greatly to its interest. It was nice once again to have the privilege of seeing old friends and making new acquaintances, which in itself is no small contribution to the success of a meeting. For perhaps one of the most pleasant aspects of any annual meeting is the exchange of ideas in conversation outside the scientific meeting room.

This year's Caldwell Lecture which was given by Dr. Andrew Conway Ivy, Nathan Smith Davis Professor of Physiology, Northwestern University Medical School, on "Motor Dysfunction of the Biliary Tract: An Analytical and Critical Consideration" was one of the highlights of the meeting. Dr. Ivy, who has devoted years to research on the gastrointestinal tract as well as the biliary tract, discussed the problems relating to the normal as well as the pathologic function of the gallbladder and its tract, relating the known facts and putting into bold relief many of the unsolved problems concerning the biliary tract in which roentgenological studies themselves might be of considerable aid in their elucidation.

Indeed the entire program was of such a nature as to appeal to all those interested in scientific developments and advancements of roentgenology.

Then, too, the members of the Society and their guests had the privilege of once again viewing the technical advances which had been made in roentgen apparatus, drugs, etc., in the intervening years since the former annual meetings. These exhibits were displayed in the Hall of Mirrors and in the adjoining rooms.

Dr. Donaldson, the Chairman of the Scientific Exhibits and his committee arranged a splendid exhibit which was one of the important functions of the meeting and attracted an unusual amount of interest and favorable comment. A brief description of the scientific exhibits is given elsewhere in this issue of the JOURNAL.

The social aspects of the meeting which were arranged by Dr. Reineke and his local committee were all that one could anticipate for nowhere are the social aspects of a meeting more enjoyed than in Cincinnati which has always set a very high standard of entertainment. Particularly is the Ladies' Entertainment Program Committee to be congratulated and thanked for the fine entertainment which they arranged for the wives of the members and their guests. The annual golf tournament was well attended and the competition for the Willis F. Manges Trophy was keen.

Dr. Kirklin, the Director of the Instructional Courses, reports an unusual interest in these courses, all of which were well attended, and the arrangement of the program was such that full attendance at the Instructional Courses was possible.

It may be said in passing that no hotel in which the Society has convened has offered better facilities for the meeting than the Netherland Plaza, and to the personnel of the hotel the Society offers its thanksfor their cooperation in making the 1946 annual meeting the success which was anticipated.

WALTER SIBLEY LAWRENCE
1867-1946

WALTER SIBLEY LAWRENCE died on July 6, 1946, at his home, 1622 Central Avenue, Memphis, Tennessee, from cardiac failure, after an illness of almost two years.

Dr. Lawrence, a member of the American Roentgen Ray Society since 1917, was born July 28, 1867, in Cambridge, England. His parents were the Reverend J. P. Lawrence, an Episcopal clergyman, and Amelia Sibley Lawrence. His father held a ministry in Staunton, Virginia, where Dr. Lawrence spent his childhood after the age of twelve. After attending the University of Virginia,

Dr. Lawrence transferred to the University of Tennessee, receiving the degree of B.S. in 1891. In 1900 he received his M.D. degree from Vanderbilt University. Shortly after beginning practice in Memphis, he became interested in radiology, and for twenty-five years before his death he was Professor of Radiology at the Medical School of the University of Tennessee. His principal interest was in radiation therapy.

He was married on April 5, 1910, to Miss Merle Mauldin, who survives him. He leaves also a daughter, Mrs. Reid Bondurant of Memphis, and two grandchildren, three sisters and one brother. He was a communicant of Grace-St. Luke's Episcopal Church.

In addition to be a golfer and a gardener, Dr. Lawrence wrote poetry. His friends look forward to a compilation of his verse, contemplated by one of his sisters.

Ramsay Spillman

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual meeting: 1947, to be announced.

American College of Radiology
Secretary, Mac F. Cahal, 20 N. Wacker Drive, Chicago 6. Annual meeting: 1947, to be announced.

Section on Radiology, American Medical Association
Secretary, Dr. U. V. Portmann, Cleveland Clinic, Cleveland, Ohio. Annual meeting: 1947, to be announced.

American Radium Society
Secretary, Dr. H. F. Hare, 605 Commonwealth Ave., Boston, Mass. Annual meeting: 1947, to be announced.

Arkansas Radiological Society
Secretary, Dr. Fred Hames, 511 National Bldg., Pine Bluff, Ark. Meets every three months and also at time and place of State Medical Association.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Palmer House, Chicago, Ill., Dec. 1–6, 1946.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Section on Radiology, California Medical Association
Secretary, Dr. D. R. MacColl, 2007 Wilshire Blvd., Los Angeles 5, Calif.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Radiological Section, Los Angeles Co. Med. Assn.
Secretary, Dr. Roy W. Johnson, 1407 S. Hope St., Los Angeles, Calif. Meets on second Wednesday of each month at the County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. A. H. Levy, 1354 Carroll St., Brooklyn 13, N. Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

Chicago Roentgen Society
Secretary, Dr. F. H. Squire, 1754 W. Congress St., Chicago 12, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. Carroll C. Dundon, 11311 Shaker Blvd., Cleveland, Ohio. Meetings at 6:30 P.M. on fourth Monday of each month from October to April.

Dallas-Fort Worth Roentgen Study Club
Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meets in Dallas on odd months and in Fort Worth on even months, on third Monday, 7:30 P.M.

Denver Radiological Club
Secretary, Dr. W. C. Huyler, 1619 Milwaukee, Denver 6, Colo. Meets third Friday of each month at Department of Radiology, Colorado School of Medicine.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

Florida Radiological Society
Secretary, Dr. J. M. Dell, Jr., 333 W. Main St., S., Gainesville, Fla. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. J. A. Campbell, Indiana University Hospitals, Indianapolis 7. Meets second Sunday in May.

Iowa X-Ray Club
Secretary, Dr. Arthur W. Erskine, 326 Higley Bldg., Cedar Rapids, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. Special meetings by announcement.

Kentucky Radiological Society
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

Michigan Association of Roentgenologists
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. Annette T. Stenstrom, 1218 Medical Arts Bldg., Minneapolis, Minn. One meeting a year at time of Minnesota State Medical Association.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Neb. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

* Secretaries of societies not here listed are requested to send the necessary information to the Editor.

New England Roentgen Ray Society
Secretary, Dr. George Levene, Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday, Boston Medical Library

New Hampshire Roentgen Ray Society
Secretary, Dr. A. C. Johnston, Elliott Community Hospital, Keene, N. H. Meets four to six times yearly.

Radiological Society of New Jersey
Secretary, Dr. W. H. Seward, Orange Memorial Hospital, Orange, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

New York Roentgen Society
Secretary, Dr. Ramsay Spillman, 115 East 61st St., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

North Carolina Radiological Society
Secretary, Dr. J. E. Hemphill, 323 Professional Bldg., Charlotte 2, N. C. Meets in May and October.

North Dakota Radiological Society
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

Central New York Roentgen Ra Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

Ohio Radiological Society
Secretary, Dr. Henry Snow, 1061 Reibold Bldg., Dayton, Ohio. Meets during annual meeting of Ohio State Medical Association.

Orleans Parish Radiological Society
Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets first Tuesday of each month.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. J. M. Converse, 416 Pine St., Williamsport.

Philadelphia Roentgen Ray Society
Secretary, Dr. C. L. Stewart, Jefferson Hospital. Meets first Thursday of each month, October to May, at 8:00 P.M., in Thomson Hall, College of Physicians.

Pittsburgh Roentgen Society
Secretary, Dr. L. M. J. Freedman, 115 South Highland Ave. Meets 6:30 P.M. at Webster Hall Hotel on second Wednesday each month, October to May inclusive.

Portland Roentgen Club
Secretary, Dr. Selma Hyman, University of Oregon Medical School, Portland, Oregon. Meets monthly 2d Wednesday, 8:00 P.M., Library of University of Oregon Medical School.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Murray P. George, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

St. Louis Society of Radiologists
Secretary, Dr. Edwin C. Ernst, Beaumont Medical Building, St. Louis, Mo. Meets fourth Wednesday of each month, except June, July, August, and September.

San Diego Roentgen Society
Secretary, Dr. R. F. Niehaus, 1831 Fourth Ave., San Diego, Calif. Meets monthly, first Wednesday at dinner.

San Francisco Radiological Society
Secretary, Dr. Joseph Levitin, 516 Sutter St., San Francisco 2, Calif. Meets monthly on the third Thursday at 7:45 P.M., first six months of the year at Lane Hall, Stanford University Hospital, and second six months at Toland Hall, University of California Hospital.

Shreveport Radiological Club
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. R. P. O'Bannon, 650 Fifth Ave., Fort Worth 4, Texas.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Utah Radiological Conference
Secretary, Dr. Henry H. Lerner, School of Medicine, University of Utah, Salt Lake City 1. Meets 1st and 3rd Thursdays monthly from 7:30 to 10 P.M., Salt Lake County General Hospital, September to June.

Utah State Radiological Society
Secretary, Dr. M. Lowry Allen, Judge Bldg., Salt Lake City 1, Utah. Meets third Wednesday in September, November, January, March and May.

Virginia Radiological Society
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. Thomas Carlile, 1115 Terry St., Seattle. Meets fourth Monday each month, October through May, College Club, Seattle.

X-Ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly, third Thursday evening.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

Mexico

Sociedad Mexicana de Radiologia y Fisioterapia
General Secretary, Dr. D. P. Cossio, Marsella No. 11, Mexico, D. F. Meets first Monday of each month.

British Empire

British Institute of Radiology Incorporated with the Roentgen Society
Medical Members' meeting held monthly on third Friday at 2:30 P.M. and Ordinary Meeting at same time on following Saturday, October to May, 32 Welbeck St., London, W.1.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets third Friday each month at 4:45 P.M. at the Royal Society of Medicine, 1 Wimpole St., London.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 23 Welbeck St., London, W.1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. J. W. McKay, 1620 Cedar Ave., Montreal.

Société Canadienne-Francaise d'Electrologie et de Radiologie Médicales
Secretary, Dr. Origéne Dufresne, 4120 Ontario St., East, Montreal, P. Q.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

South America

Sociedad Argentina de Radiologia
Secretary, Dr. Guido Gotta, Buenos Aires, Argentina. Meetings are held monthly.

Sociedad Peruana de Radiologia
Secretary, Dr. Julio Bedoya Paredes, Apartado, 2306 Lima, Peru. Meetings held monthly except during January, February and March, at the Asociación Médica Peruana "Daniel A. Carrión," Villalta, 218, Lima.

Continental Europe

Ceskoslovenská společnost pro röntgenologii a radiologii v Praze
Secretary: MUDr. Roman Blána, Praha XII, Korunní 160, Czechoslovakia.

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. Babaiantz, Geneva.
Secretary for German language, Dr. Max Hopf, Effingerstrasse 49, Bern. Meets annually in different cities.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banual Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

SCIENTIFIC EXHIBIT

The Scientific Exhibit at the Forty-seventh Annual Meeting of the American Roentgen Ray Society held at the Netherland Plaza, Cincinnati, Ohio, September 17–20, 1946, was, as always, one of the most instructive features of the meeting and was arranged by the Chairman of the Scientific Exhibits, Dr. S. W. Donaldson, and his Committee. A description of the exhibits, with awards given, follows:

An exhibit entitled "The Roentgenologic Contribution to the Diagnosis of Meckel's Diverticulum" was presented by Drs. H. M. Weber and C. A. Good, Jr., Mayo Foundation for Medical Education and Research, Rochester, Minn. Meckel's diverticulum has been called the most common congenital anomaly of the intestinal tract. The roentgenologic examination can be made to exhibit Meckel's diverticulum as such in a certain percentage of cases but its chief contribution to the diagnosis of Meckel's diverticulum is in ruling out other lesions of the small intestine which produce the same symptoms and signs. The exhibit illustrated by roentgenograms the experience of the Section on Roentgenology at the Mayo Clinic with the diagnosis of Meckel's diverticulum in its various manifestations. This exhibit received Honorable Mention.

The next exhibit was entitled "The Effect of Irradiation upon the Minute Blood Vessels and Lymph Flow of the Skin. A Clinical and Experimental Study." This was from the Department of Radiology and the Robinette Foundation of the Medical Clinic of the Hospital of the University of Pennsylvania, Philadelphia, Pa., and was presented by Drs. Eugene P. Pendergrass, Robert H. Ivy (by invitation), John Q. Griffith, Jr. (by invitation), Charles R. Perryman (by invitation), Stuart P. Barden (by invitation), Philip J. Hodes, and Robert P. Barden. The exhibit consisted of charts, photographs and drawings. The clinical material consisted of studies of the thigh area in human volunteers following varied roentgen dosage. Included were simple observation of the area, capillary microscopy and, after the interval of at least a year, biopsy followed by histologic study. The experimental material consisted of studies, largely with animals, describing the effect of radiation on cutaneous lymphatic flow, capillary permeability and fragility, and tendency to venous thrombosis. Comparison was made, in certain respects, between irradiation by roentgen rays and radon. The following procedures or medicaments were described and their effect on the cutaneous reaction to irradiation in animals: (1) sympathectomy; (2) experimental hyperthyroidism; (3) dicoumarin; (4) rutin. The skin changes were illustrated with beautiful color trans-

parencies. This exhibit was awarded the Gold Medal.

"Myelography in the Diagnosis of Herniations of Cervical Intervertebral Discs" was the title of an exhibit arranged by Drs. Arthur B. Soule, Jr., and Frederick W. VanBuskirk (by invitation), University of Vermont College of Medicine, Burlington, Vermont. The exhibit consisted of transparencies including a brief description of protrusions of cervical intervertebral discs, incidence, symptoms and signs, roentgen findings, technique of cervical myelography, indications for operation and technique of operation. It was illustrated with drawings, photographs and roentgenograms of proved cases.

Of considerable diagnostic value and interest was an exhibit entitled "Abdominal Aortography: Technique and Clinical Application" by Drs. Paul C. Swenson, Frederick B. Wagner, Jr. (by invitation), and Calvin L. Stewart (by invitation), Jefferson Hospital, Philadelphia, Pa. This exhibit showed translumbar puncture of the abdominal aorta for injection of contrast media; techniques of injection and roentgenological examination. Cases were exhibited showing reproductions of films, indication for examination, and conclusions. A paper on the same subject was given in the scientific program.

An exhibit of timely interest was one entitled "Poisoning in Beryllium Production: Chemical Pneumonitis and Dermatitis" by Drs. H. S. VanOrdstrand (by invitation), Robert Hughes (by invitation), Cleveland Clinic, Cleveland, Ohio; Drs. J. M. DeNardi (by invitation), Lorain, Ohio, and Morris G. Carmody (by invitation), Painesville, Ohio. Almost all beryllium used is derived from the ore beryl, which is imported chiefly from Brazil and Argentina, although some deposits are being worked in South Dakota, Maine, and New Hampshire, and British India. The exhibit demonstrated clinical and pathological findings in workers processing beryllium from the raw ore. The demonstration showed respiratory, dermatological, and ocular manifestations. Chemical pneumonitis was emphasized including material from four autopsied cases. The exhibit contained many illustrations in color. It was a very comprehensive one and beautifully arranged. The exhibit also contained samples showing beryllium, its production, fabrication and application. At the present time the element beryllium is playing such a strategic part in the development of nuclear fission that the ore supply is under direct control of the government. This exhibit was given Honorable Mention.

"Differential Diagnosis of Abdominal Tumors" was the title of an exhibit by Drs. Samuel Brown (by invitation), J. E. McCarthy, and Archie Fine (by invitation), Jewish Hospital, Cincinnati, Ohio. Roentgenograms were presented of the stomach and duodenum in the anterior and lateral positions showing their relationship to their neighboring structures in three dimensions. Tumors of liver, spleen, pancreas, gallbladder, extrabiliary ducts and kidneys were shown, the diagnosis of which was determined by the characteristic changes each one of them produces upon the position, shape and contour of the stomach and the duodenum.

An exhibit entitled "Bronchography in Childhood Tuberculosis" was presented by Dr. Eduardo Rivero (by invitation), Santorio Infantil Aballi, Havana, Cuba. This consisted of a series of bronchograms taken in children with primary tuberculosis, showing the alterations of the bronchi caused by infiltration, compression from enlarged lymph glands, atelectasis and endobronchial lesions. This was one of the most comprehensive and informative exhibits shown and was awarded the Bronze Medal. A paper on the same subject was given in the scientific program.

"Radiation Injury and Tolerance Dose of Normal Stomach" was the title of an exhibit by Drs. Aubrey O. Hampton, Milton Friedman (by invitation), Irving B. Brick (by invitation), and Ellery M. James (by invitation), Walter Reed General Hospital, Washington, D. C. During the course

of irradiating retroperitoneal nodes in cases of carcinoma of the testis with supervoltage roentgen rays, many patients developed atypical symptoms of peptic ulcer. Roentgenographic examination revealed unusual lesions of the stomach, many with ulcers. Some ulcers improved under medical treatment; others required partial gastric resection. In the exhibit, these lesions were described roentgenographically and with kodachrome photographs and photomicrographs. The tolerance tissue dose of the stomach was discussed. In all supervoltage roentgen therapy, it becomes necessary to know the tolerance dose of the normal deep structures rather than the skin. This exhibit was given Honorable Mention.

An exhibit entitled "Relationship of Pulmonary Calcification to Histoplasmin Sensitivity" was presented by Drs. Amos Christie (by invitation), and J. C. Peterson (by invitation), Pediatric Department, Vanderbilt Uuiversity Medical School, Nashville, Tenn. This consisted of charts showing correlation of pulmonary calcification to histoplasmin sensitivity and maps showing geographical distribution of histoplasmin sensitivity. One chart showed the age distribution. There were a number of roentgenograms showing the nature of the calcification, and cultures and photomicrographs showing benign and malignant histoplasmosis. A paper on the same subject was given in the scientific program. This was one of the most important and instructive exhibits at the meeting.

"Spondylolisthesis: A Congenital Anomaly Frequently Unaccompanied by Symptoms" was the title of an exhibit by Dr. Wilbur Bailey, University of Southern California Medical School, Los Angeles, Calif. This was an exhibit of roentgenograms, posters and placards showing the main points of spondylolisthesis and its precursors. Special attention was directed to the congenital origin of this disease and the fact that it is frequently discovered in the absence of symptoms.

"Roentgenologic Demonstration of Tumors of the Thymus in Myasthenia Gravis" was the title of an exhibit by Dr. C. Allen Good, Jr., Mayo Foundation for Medical Education and Research, Rochester, Minn. This consisted of transparencies of roentgenograms and pathologic specimens in cases of myasthenia gravis with associated thymic tumor. There was also a demonstration consisting of a moulage of the mediastinum, including the various types of tumor of the thymus. Case histories accompanied the roentgenograms. This exhibit was given Honorable Mention. A paper on the same subject was given in the scientific program.

Another valuable and interesting exhibit was entitled "Electrokymography Utilizing the Fluoroscope" by Drs. W. Edward Chamberlain and George Henny, Temple University Medical School, Philadelphia, Pa. The exhibit demonstrated a new method of recording the movements of selected points on the borders of the fluoroscopic heart shadow. A photomultiplier tube (same as used in the Morgan-Hodges phototimer) produces an electric current which varies with the amount of light which it receives. As the heart border moves in and out, it acts as a variable shutter, and the recording galvanometer of an ordinary electrocardiograph produces a graphic tracing of the heart border motion. The method has already made a place for itself in the Physiology Laboratory as well as in Clinical Cardiology. This exhibit was awarded the Silver Medal.

"Tumors and Chronic Inflammatory Diseases of the Small Intestine" was the title of an exhibit by Dr. Barton R. Young, Temple University Medical School, Philadelphia, Pa. This exhibit was made up of a number of illustrations revealing changes in morphology and motility of the small intestine on the basis of chronic inflammatory and neoplastic diseases. Emphasis was placed on the abnormalities in the small intestine, detected by roentgen examination, in patients with regional enteritis, especially the smooth unusually multiple stricture, separated by normal appearing sections of bowel (skip areas). Chronic

tuberculosis of the small intestine may result in stricture formation and therefore the roentgen findings in this condition were presented and differentiated from those obtained in non-tuberculous regional enteritis. The exhibit included illustrations of severe small intestinal changes with obstructive manifestations in protracted deficiency disease (non-tropical sprue) and eosinophilic granuloma. The roentgen findings of several tumors of the small bowel including carcinoma, malignant carcinoid and hemangioma were demonstrated. The roentgenograms of the above mentioned conditions were supplemented by photographs of the surgical specimens and the histopathology.

An exhibit entitled "Solitary Tumors of the Chest: Diagnosis in 50 Proved Cases" was presented by Dr. Robert K. Arbuckle (by invitation), Temple University, Philadelphia, Pa. Tumors of the chest having a spherical or oval contour present diagnostic difficulties by roentgenographic study. A group of 50 proved cases was analyzed to determine which diagnostic procedures are of the greatest value in arriving at an exact diagnosis. Among the tumors were examples of carcinoma of the lung, dermoids, nerve sheath tumors, etc.

"Bronchography" was the title of an exhibit by Dr. Samuel S. Peoples (by invitation), Temple University Medical School, Philadelphia, Pa. This exhibit was prepared to show the value and wide application of bronchography in the study of diseases of the chest. Essential anatomic considerations were brought out with illustrations of bronchograms of normal lungs. The technique employed in the Department of Roentgenology of the Temple University Hospital in conjunction with the Chevalier Jackson Department of Bronchology was explained, including nomenclature of the bronchopulmonary segments. Bronchograms in various lung conditions were shown to demonstrate the importance of this method for localization. The exhibit presented material on a wide variety of problems including the following: (1) cases in which conventional roentgenograms revealed little or no abnormality while bronchograms revealed disease; (2) cases in which the bronchograms provided the indications or contraindications for surgery, in such conditions as bullous emphysema, bronchiectasis, etc.; (3) cases in which bronchograms give remarkable visualization of alteration of the volume of various lobes.

Another exhibit from the Temple University Medical School, Philadelphia, Pa., was presented by Dr. Samuel H. Fisher (by invitation) and was entitled "The Diaphragm in Health and Disease." The common variations in the outline of the diaphragm caused by tenting, costal interdigitations, local weaknesses and displacement by gaseous distended viscera were illustrated. The pathologic conditions presented were obscuration by parenchymal inflammatory disease (bronchiectasis); displacement by subdiaphragmatic abscess, a calcified cyst of the liver; two cases of primary tumors of the liver were shown with their effects on the diaphragm. The exhibit also included eventration of the diaphragm, diaphragmatic hernias including that seen with congenital short esophagus, paraesophageal hernia, hernias through the foramen of Bochdalek and the foramen of Morgagni. A case of paralysis of the diaphragm by invasion of the phrenic nerve with bronchogenic carcinoma was shown; roentgenograms were presented exposed at the height of inspiration and during the "sniff" test.

Dr. G. E. Richards, Ontario Institute of Radiotherapy, Toronto General Hospital, Toronto, Ontario presented a "Demonstration of Instrument for Aspiration Biopsies" and "Demonstration of Improved Applicators for Radium Treatment of Carcinoma of the Cervix Uteri." Included also in the exhibit was an analysis of technical factors and results of treatment of carcinoma of the cervix uteri. A paper on the same subject was presented in the scientific program.

"Boeck's Sarcoidosis in Youth of Mili-

tary Age" was the title of an exhibit presented by Drs. Bernard Roswit (by invitation) and Archie Scheimel (by invitation), Veterans Administration, Bronx, N. Y. Boeck's sarcoid is an intriguing and provocative diagnostic and therapuetic problem of rising importance and rapidly increasing frequency, affecting principally youth of military age. This exhibit was drawn from a study of 26 cases (13 proved by biopsy) in the U. S. Veterans Hospital, Bronx, New York, Department of Radiology. This potentially systemic disease has an elusive and controversial etiology. The histological unit is the "hard tubercle." The clinical picture is chameleon in character with periodic exacerbations and systemic involvement. No organ is immune, but the lungs and bones show the more interesting pathology. The course of the disease is unpredictable and chronic, with spontaneous regression or progression to death from pulmonary tuberculosis. There is yet no effective therapy for this disease. The exhibit presented all of the interesting ramifications of the problem.

Dr. Herman E. Hilleboe presented (by invitation) from the United States Public Health Service, Washington, D. C. an interesting exhibit on "Miniature Film Mass Roentgenography of the Chest." This was a pictorial and chart representation of mass roentgenography of the chest showing method of examination and comparison of 35 mm., 70 mm., and 4 by 5 inch films and graphs of estimated significant chest pathology per one thousand patients routinely examined on general hospital or clinic admission. A paper on this subject was given in the scientific program.

An exhibit entitled "Roentgenology of the Mastoid" was presented by Drs. Frank Windholz (by invitation), and Harold A. Fletcher (by invitation), Stanford University School of Medicine, Department of Radiology, San Francisco, Calif. This exhibit consisted of 168 translucencies in cardboard mountings. Most of the roentgenograms were accompanied by explanatory drawings. They illustrated normal and pathological conditions. The development and standardization of roentgenographic technique and roentgen anatomy of standard views were illustrated on drawings, photographs and roentgenograms of bone specimens and of patients. The significance of variations of technique and of anatomy was stressed. Developments, types and disturbances of pneumatization were shown according to the theory of Wittmaack. The roentgen appearance of acute and chronic otitis media and of its complications, mastoiditis and petrositis and cholesteatomas, were dealt with in detail. Types of defects after operations, tumors, fractures, foreign bodies and malformations were exhibited. The most frequent roentgenological errors were illustrated on roentgenograms.

A very interesting exhibit was that presented by Dr. Lewis E. Etter (by invitation), Pinewood Farms, Warrendale, Pa., entitled "Post-War Views of Röntgen's Laboratory, September, 1945." This included an exhibit of books, correspondence and photographs pertaining to the life of Röntgen, as well as the views of Röntgen's laboratory taken in 1945. Several papers by Dr. Etter on this subject have been published in the JOURNAL. This exhibit was given Honorable Mention.

An exhibit entitled "Congenital Malformations Induced in Rats by Roentgen Rays: Skeletal Changes in the Offspring Following a Single Irradiation of the Mother" was presented by Drs. Josef Warkany (by invitation), and Elizabeth Schraffenberger (by invitation), Children's Hospital Research Foundation, Cincinnati, Ohio. Congenital malformations were obtained in the offspring of female rats which were exposed to roentgen rays on certain days of pregnancy. Defects of the bones of the skull, cleft palate, shortness of the mandible and malformations of the ribs and of the bones of the arms and legs were observed. Certain patterns of deformities could be established which depended upon the day of irradiation and upon the dose of roentgen rays administered. The

exhibit consisted of specimens of newborn rats cleared by the Schultze-Dawson method. They were beautifully mounted in a a stand which supplied a magnifying glass for careful study of the specimens. This exhibit was given Honorable Mention. A paper on the same subject was presented in the scientific program.

"Supervoltage Radiation" was the title of an exhibit presented by Dr. Milford D. Shulz, Massachusetts General Hospital, Boston, Mass. This consisted of charts showing the results obtained in the treatment of patients with malignant tumors of the more common types with supervoltage radiation at the Collis P. Huntington and the Massachusetts General Hospitals. A paper on the same subject was given in the scientific program.

An exhibit entitled "Rapid and Convenient Method of Copying Roentgenograms" was presented by Drs. Eugene Saenger (by invitation), Children's Hospital, Cincinnati, Ohio, and David R. Limbach, Georgia Baptist Hospital, Atlanta, Georgia. The original films and miniature reproductions were shown in this exhibit and a simple method of making the reproductions.

An exhibit entitled "Opportunities for Radiologists—Veterans Administration" was presented by Dr. A. O. Hampton, Director for Radiology, Veterans Administration, Washington, D. C. This was an exhibit showing by charts, maps and photographs the many opportunities in the Veterans Administration for radiologists. Those radiologists who are interested may secure information by writing to Dr. Hampton.

"Dosage Calculations in Radium Therapy" was the title of an exhibit by Edith H. Quimby, Sc.D., Columbia University, New York. This exhibit included various charts and directions for the proper dosage calculations in radium therapy.

Another most interesting exhibit consisted of the two gavels which have been presented to the American Roentgen Ray Society. One was the gavel presented to the Society in 1930 by Dr. George E. Pfahler of Philadelphia. This beautiful gavel was made from Alaskan ivory, the tusks more than a million years old. The second gavel was presented to the Society by Dr. Arthur W. Erskine, Cedar Rapids, Iowa, at this Forty-seventh Annual Meeting. This unique gavel was handmade by Dr. Erskine and consists of the wooden base of Röntgen's microscope—the head of the gavel; a piece of the roll top desk Dr. W. D. Coolidge used during the years he worked on the roentgen tube and ductile tungsten for lamps makes up the handle of the gavel. The block and its mahogany inlay with a sine wave making up the sounding board are from part of one of the early Snook machines. It can be seen even from this brief description that the word "unique" was used advisedly for it is beyond the realm of probability that wood from such historical materials could be made available for another gavel or that it would have the handicraft of Dr. Erskine for its fashioning. The Society is indeed fortunate in having in its possession two such beautiful and historically interesting gavels.

COMMERCIAL EXHIBIT

The Commercial Exhibit at the Forty-seventh Annual Meeting of the American Roentgen Ray Society held at the Netherland Plaza, Cincinnati, Ohio, September 17–20, 1946, was one of the best both in the matter of size and quality which has ever been arranged at any meeting of the Society. This can be seen in the fact that twenty-seven manufacturers had reserved a total of sixty-two booths and that 252 commercial exhibitors were registered at the meeting. The exhibits filled the beautiful Hall of Mirrors and extended into the third floor foyer and occupied part of the South Hall where the scientific exhibits were held.

The exhibitors gave much time and thought to the backgrounds for their exhibits. These added greatly to the effective display of the roentgenologic apparatus and the various products of interest to radiolo-

gists. The intellectual requirements of the radiologists were not neglected as three book publishers were represented with attractive displays of their books. Much of the roentgenological equipment was new and since this was the first opportunity in a long time that many or most radiologists had had to talk with the manufacturers and see the innovations, there was a constant attendance at all of the booths.

The Society is most appreciative of the continued interest shown by the manufacturers in the meeting.

The following firms were represented in the Commercial Exhibit: *Allis-Chalmers Manufacturing Company*, Milwaukee, Wisconsin; *Ansco*, Binghamton, N. Y.: *Buck X-Ograph Company*, St. Louis, Mo.; *Canadian Radium and Uranium Corporation*, New York, N. Y.; *E. I. Du Pont de Nemours and Company*, Wilmington, Delaware; *Eastman Kodak Company*, Rochester, N. Y.; *Eureka X-ray Tube Corporation*, Chicago, Ill.; *General Electric X-Ray Corporation*, Chicago, Ill.; *Thomas B. Gibbs and Company*, Delavan, Wisconsin; *Paul B. Hoeber, Inc.*, New York, N. Y.; *Kelley Koett Manufacturing Company*, Covington, Kentucky; *Liebel-Flarsheim Company*, Cincinnati, Ohio; *Machlett Laboratories*, Springdale, Conn.; *F. Mattern Manufacturing Company*, Chicago, Ill.; *Wm. Meyer Company*, Chicago, Ill.; *National Synthetics*, New York, N. Y.; *North American Philips Company*, New York, N. Y.; *Picker X-Ray Corporation*, New York, N. Y.; *Schering Corporation*, Bloomfield, N. J.; *Frank Scholz*, Boston, Mass.; *Standard X-Ray Company*, Chicago, Ill.; *Charles C Thomas*, Springfield, Ill.; *Victoreen Instrument Company*, Cleveland, Ohio; *Westinghouse Electric Corporation*, Pittsburgh, Pa.; *Winthrop Chemical Company*, New York. N. Y.; *Year Book Publishers*, Chicago, Ill.; *York Microstat Corporation*, Chicago, Ill.

NEW OFFICERS

At the Forty-seventh Annual Meeting of the American Roentgen Ray Society held at the Netherland Plaza, Cincinnati, Ohio, September 17–20, 1946, the following officers were elected for the year 1946–1947: *President-Elect:* J. Bennett Edwards, Leonia, N. J.; *1st Vice-President:* Walter W. Wasson, Denver, Colo.; *2nd Vice-President:* Paul A. Bishop, Philadelphia, Pa.; *Secretary:* H. Dabney Kerr, Iowa City, Iowa (re-elected); *Treasurer:* Wendell G. Scott, St. Louis, Mo.; *Member of the Executive Council:* W. Edward Chamberlain, Philadelphia, Pa. The *President* is Raymond C. Beeler, Indianapolis, Ind., and the *Chairman of the Executive Council* is Harry M. Weber, Rochester, Minn.

RESERVATIONS SHOULD BE MADE FOR HAVANA CONGRESS

Nearly three hundred reservations have been made for North American radiologists and their families who will attend the Second Inter-American Congress of Radiology to be held in Havana, September 17 to 22, 1946, according to an announcement by Dr. James T. Case, chairman of the General Committee for the United States. The block of rooms reserved at the Nacional, the headquarters hotel, have long since been disposed of. Additional reservations are being made at The Sevilla-Biltmore.

Requests for hotel accommodations should be directed to Mr. Mac F. Cahal, secretary of the committee, in care of the American College of Radiology, 20 North Wacker Drive, Chicago 6, Illinois.

Delegates must arrange for air or rail transportation through their local travel agent. Special trains will be operated by the Illinois Central from Chicago and the Atlantic Coast Line from New York. Reservations for the Illinois Central should be made with Mr. J. C. La Combe, 140 South Dearborn, Chicago 3, and for the Atlantic Coast Line with Mr. R. S. Voigt, 16 East 44th Street, New York 17, New York.

Reservations for special flights to be operated from Chicago and New York to Miami by Eastern Airlines may be made in Chicago at 120 South Michigan, Chicago 3,

or in New York at Park Avenue and 42nd St., New York 17.

All delegates will be forced to go via air from Miami to Havana, and return. No steamship service will be available. Reservation forms for Pan American Airways may be obtained from Mr. Cahal.

The weather in Havana in November will be warm. Spring clothes are decreed. Passports are not required.

In addition to the sixteen papers to be read by United States radiologists, there will be eighteen scientific exhibits by delegates from this country. It is expected that copies of the printed program will be available for registered delegates soon.

Representatives on the General Committee for the United States from the three cooperative societies are Dr. James T. Case, Dr. W. Edward Chamberlain, Dr. Ross Golden, Dr. Leon J. Menville, Dr. E. P. Pendergrass, Dr. B. H. Orndoff, and Mr. Mac F. Cahal.

NATIONAL INSTITUTE OF HEALTH RESEARCH FELLOWSHIPS

The United States Public Health Service announces the continuation of the National Institute of Health Research Fellowships which were created in 1945. An increased number of these fellowships will be available during 1946 and 1947.

The National Institute of Health Research Fellowships are awarded to individuals who have had postgraduate work in institutions of recognized standing in the various fields of science allied to public health, as biology, chemistry, physics, entomology, medicine, dentistry, veterinary medicine, etc.

Applications for these fellowships may be made at any time during the year, are acted upon promptly, and are effective for one year from the time of award with a possibility of renewal for a second year.

Junior research fellowships are available to individuals holding master's degrees or to those who have completed an equivalent number of hours of postgraduate study. The stipend is $2400 per annum.

Senior research fellowships are available to individuals holding doctorate degrees. The stipend is $3000 per annum.

These fellowships will offer an opportunity for study and research in association with highly trained specialists in the candidate's chosen field at the Institute or some other institution of higher learning.

Letters of inquiry should be addressed to The Director, National Institute of Health, Bethesda 14, Maryland.

AMERICAN COLLEGE OF RADIOLOGY

At the annual meeting of the American College of Radiology held in San Francisco on June 29, 1946, the following officers were elected for the year 1946–1947: *President:* Edward H. Skinner, Kansas City, Mo.; *Vice-President:* Edwin C. Ernst, St. Louis, Mo.; *Treasurer:* Warren W. Furey, Chicago, Ill.; Raymond C. Beeler, Indianapolis, Ind., and Edgar C. Virden, Kansas City, Mo., were elected to four year terms on the Board of Chancellors. Ralph S. Bromer, Bryn Mawr, Pa., was elected to the Board of Chancellors for the one year term as representative of the American Roentgen Ray Society; Sidney J. Hawley, Seattle, Wash., was elected to the Board for a one year term as representative of the Radiological Society of North America, and Douglas Quick, New York, was elected to the Board for a one year term as representative of the American Radium Society.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY

The Rocky Mountain Radiological Society held its Midsummer Radiological Conference in Denver, Colorado, August 8, 9 and 10, 1946. Dr. Ross Golden, Dr. H. Dabney Kerr, Dr. William E. Costolow and Dr. John D. Camp were guest speakers. The following officers were elected for the ensuing year: *President:* Lewis G. Allen; *President-elect:* James P. Kerby; *1st Vice-President:* Ira H. Lockwood; *2d Vice-President:* H. M. Berg; *Historian:* John Bouslog; *Secretary:* Alfred M. Popma.

UTAH RADIOLOGICAL CONFERENCE

There has recently been established the University of Utah Radiological Conference which is to be held the first and third Thursdays of each month from 7:30 to 10 P.M. at the Salt Lake County General Hospital from September to June. The conference is held by the Department of Radiology of the University of Utah School of Medicine for the combined purpose of graduate instruction and staff discussion of diagnostic problems. All physicians are invited to attend and to bring with them interesting or problem cases for presentation. The speaker at the first conference is to be Dr. John Caffey, Associate Professor of Pediatrics, College of Physicians and Surgeons, Columbia University and Roentgenologist to the Babies' Hospital and Vanderbilt Clinic, New York. The Secretary of the conference is Dr. Henry H. Lerner, School of Medicine, University of Utah, Salt Lake City.

AMERICAN BOARD OF RADIOLOGY

There are many Diplomates and candidates with applications on file whom we are unable to reach from their last known address. All Diplomates of the Board and candidates for examination are requested to notify the office of the Secretary of their present address.

B. R. Kirklin, *Secretary*
American Board of Radiology
Mayo Clinic, Rochester, Minn.

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., B.S., M.A., 103 Rutledge Ave. Charleston, S. C.

ROENTGENOGRAMS IN RELIEF

By CAPTAIN ELI STARR
MEDICAL CORPS, ARMY OF THE UNITED STATES

ROENTGENOGRAPHY and photography are very closely related fields. Both deal with the recording of images upon chemically treated bases; both are made possible through the use of sources of radiant energy.[1] Yet photography, through its great commercial value, has made greater strides than its sister science, roentgenography. The general disinterest of the average radiologist in dark room technique has contributed to the retarded development of roentgenography.

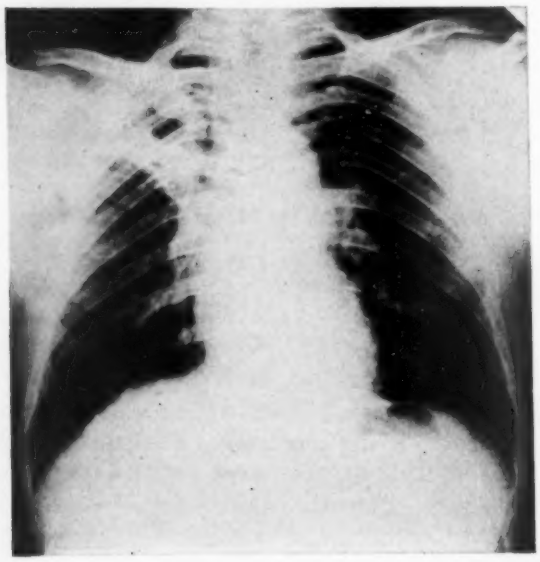

Fig. 1. Conventional roentgenogram of the chest shows a large cavity and fibrosis in the right upper lobe.

Interesting observations in photography prompted me to apply photographic methods to roentgenography at an army station hospital roentgen-ray department. Accepted procedures have been tried out with scrap roentgen film. Some of these experiences were enlightening and are being set down because they may be of general interest.

The essential steps of any type of photography are as follows:

An intermediate negative commonly referred to as the negative or intermediate is made; in it the tonal relations of the image are reversed. Then a print (facsimile) is made from the intermediate by any of the common photographic printing procedures, or by photographing the intermediate by means of suitable equipment.[3]

Duplicate negatives (intermediates) can be made by means of an intermediate positive. A film positive is made from the original negative and is then printed on another

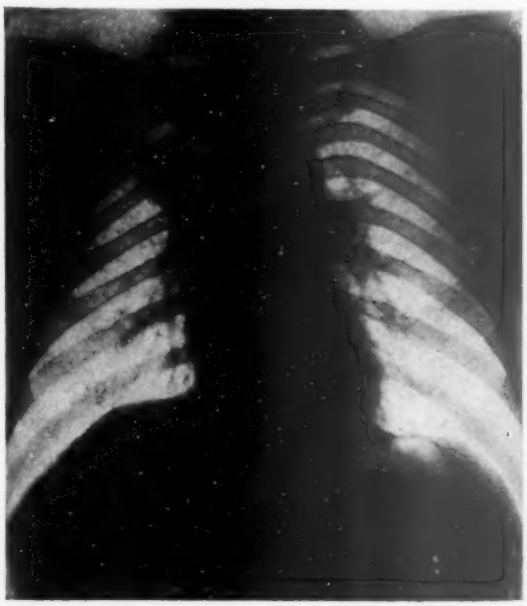

Fig. 2. Facsimile ("positive roentgenogram") of Figure 1.

piece of film to produce the duplicate.[4] Duplicate negatives can also be produced by the reversal phenomenon due to solarization, without the use of an intermediate positive.[2]

I suggest yet another method of duplicating negatives. This method can readily be used in every roentgenological department. No expenditure for additional equipment is necessary. The reproduction of facsimiles or duplicates of roentgenograms or photographs becomes a matter of a few minutes.

The back intensifying screen of an ordinary 14×17 inch cassette was removed. (Later it was found that covering the screen with black paper sufficed.) A photograph (facsimile) on velox paper was placed against the front intensifying screen with its face side toward the screen. In the dark room an unexposed film was put upon the print and the cassette was tightly closed. An exposure of 50 kv. (peak), 0.3 second, 30 ma., at 30 inch distance was made. After developing this film an intermediate of the photograph was obtained. Similar results were obtained with typewritten matter. These intermediates could be printed either by roentgenographic exposure in this cassette or by common photographic reproduction methods. Good facsimiles resulted in either instance. Thus, it was learned that the fluorescence of an intensifying screen and roentgen radiation are adequate to produce good intermediates of photographs and also that good facsimiles can be obtained from these intermediates, either by roentgenographic exposure within this modified cassette or by exposure to light in a printing frame.

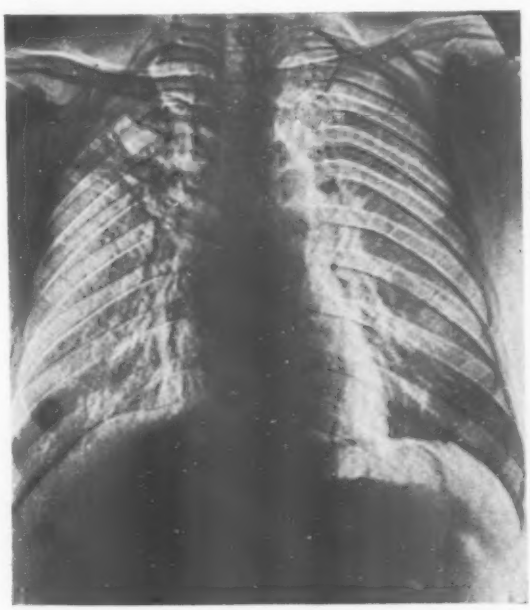

FIG. 3. Relief roentgenogram of Figure 1.

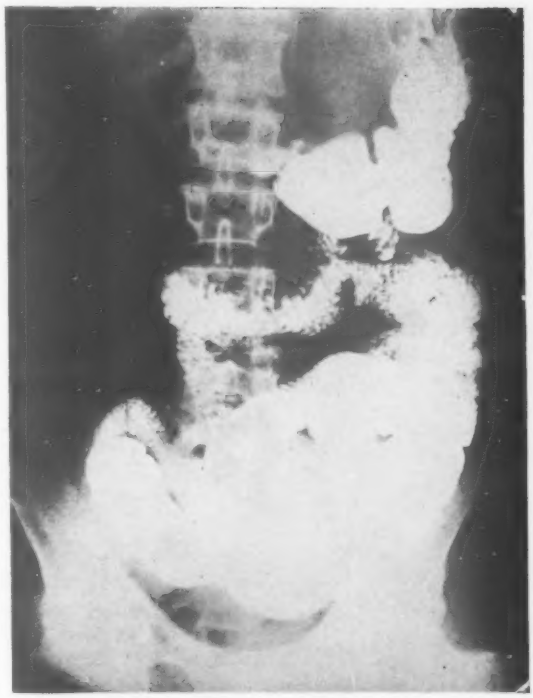

FIG. 4. Conventional roentgenogram of stomach and small intestine.

These interesting experiences were again repeated using roentgenograms in the place of photographs and printed matter. With this modified cassette, wherein the back-intensifying screen had been removed, intermediate positives of roentgenograms were made as follows:

The conventional roentgenogram was put in contact with the intensifying screen. In the dark room an unexposed film was put on top of the roentgenogram and the cassette was closed. An exposure at 50 kv. (peak), 30 ma., 0.3

Fig. 5. Facsimile ("positive roentgenogram") of Figure 4.

second, and 30 inch distance was made. The resulting film was a positive of the roentgenogram, in which the tonal relations were reversed. It is suggested that intermediate positives of roentgenograms be referred to as "positive roentgenograms."

The roentgenogram must be considered solely as a series of brightness differences, since from a photographic standpoint its details are nothing more than variations in the densities of the silver deposit.[3] The "positive roentgenogram" is the reversal of these brightness differences, the detail being recorded upon a transparent base in grays and black.

A comparison of the diagnostic qualities of the "positive roentgenogram" with the conventional roentgenogram can best be made if both are considered with respect to contrast (extent of the scales of tones) and secondly from the degree of opaqueness or density.[3] Properly exposed "positive roentgenograms" should duplicate the diagnostic qualities of the roentgenogram. There should be no loss in either contrast or density. However, technical difficulties make this quite impossible. Therefore the conventional roentgenogram is usually superior in richness of detail. True as this may be, the untrained observer expresses a preference for the "positive roentgenogram."

Medical officers who have viewed both the roentgenogram and the "positive roentgenogram" feel that the "positive" is a much richer and more natural reproduction of organs in shadow. This is very true since the "positive roentgenogram" is a facsimile of the roentgenogram upon film. Another reason for this preference is the visual impression of transillumination. The image appears interposed between the light source and the observer. This transilluminating effect imparts a sensation of relative depth, which is more apparent than real. Yet,

Fig. 6. Relief roentgenogram of Figure 4.

because of it, the "positive roentgenogram" is enriched.

Further experimentation with conventional and "positive" roentgenograms led to the consideration of roentgenograms in relief. Relief being line and shadow effect, it was realized that the superimposition of the "positive roentgenogram" upon the conventional would produce shadow effect in the roentgenogram. This was done and immediately the detail became plastic.

To attain relief effect, it is important to observe the following:

The conventional roentgenogram is mounted on the illuminator. The "positive roentgenogram" is superimposed upon it in such a manner that an approximate 5 mm. lateral shift to either the right or left is obtained. However, it is best that the "positive" be shifted from right to left until maximal relief-effect is apparent.

The average illuminator was found unsatisfactory for viewing superimposed roentgenograms for relief effect. The luminosity or intensity of light was insufficient for proper visualization. To overcome this difficulty, the daylight bulb from one of the older illuminators was removed and replaced by a photoflood No. 1 bulb. This modified illuminator enhanced the relief effect.

Both transparencies and photographs were made from these superimposed relief-producing roentgenograms. The transparencies were superior to the photographs since the range of densities in an image on a film base can be more readily seen when it is viewed by transmitted light and only a portion of the same range of densities can be seen when the image is on a paper base and is viewed by reflected light.[3] True as this is, the illustrations reproduced here do demonstrate relief effect.

SUMMARY

The fluorescence of the front intensifying screen of a cassette and roentgen radiation have been shown adequate for production of good, printable, intermediates of photographs and printed matter; and for the reproduction of facsimiles from these intermediates. Facsimiles of roentgenograms upon film have been discussed. Roentgenograms in relief resulted from the superimposing of these facsimiles upon the conventional roentgenograms.

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The author wishes to express his thanks to Major Abner Stern and Corporal Felix J. Barth for their helpful suggestions and assistance.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

GENITOURINARY SYSTEM

Draper, J. W., and Siceluff, J. G. Excretory cysto-urethrograms. *J. Urol.*, April, 1945, *53*, 539–544.

The authors have developed a technique for visualization of the bladder and urethra. Five exposures are made. The patient first voids and then lies supine on a tilt table. After introduction of a urethral catheter 120–180 cc. of air is injected slowly and the catheter clamped. A film of the bladder is exposed in the oblique position. The air is then removed and 15–20 per cent skiodan is injected through the catheter until the patient has the desire to void. The catheter is withdrawn and the table tilted to the upright position. With the pelvis tilted 30 degrees from the table and the patient's right foot resting on a 10 inch block a roentgenogram is made while the patient voids into vessel. He is asked to stop voiding and a film is exposed immediately while the sphincter muscles are contracting. The patient again voids and a penis clamp applied when the stream has been established. The patient is urged to continue to attempt to urinate against the resistance of the clamp and a film exposed to demonstrate the urethra. A final film is exposed after the bladder has been emptied.

In the article roentgenograms are reproduced to show how this technique can be employed to demonstrate bladder diverticula, urethral strictures and partial urinary incontinence following paralysis of the sacral plexus.—*R. M. Harvey.*

Pritchard, W. Notes regarding intravenous urograms based on 2000 series in eighteen years. *J. Urol.*, Feb., 1945, *53*, 387–392.

The author has reached the following conclusions as a result of his experience in performing 2,000 intravenous urograms: (1) a suitable table is required with cystoscopic and roentgen-ray facilities, which can be converted rapidly from the vertical to the Trendelenburg position, high milliamperage and a speed Bucky-Potter grid are essential; (2) the only cases in which the examination is contraindicated are patients in shock with a blood pressure below 80 and cases with marked or complete suppression of urinary secretion; (3) patients should be prepared by abstinence from fluids for eighteen hours prior to the examination and omission of breakfast the morning of the examination; (4) a rough functional test of concentrating power of the kidney is furnished by having the patient hold his urine for two hours before the test and testing the specific gravity of this retained specimen; (5) the quantity of dye to be given should be based on grams of iodine and should be proportional to the patient's weight, age and concentrating power; children can be given twice as much dye per proportionate weight as adults, and infants three times as much. In patients with poor concentrating powers the amount of dye must be increased; (6) rapid injection of the dye is essential and for this purpose the author preheats the forearm with an electric pad and selects a large vein; (7) the patient is placed in 15 degree Trendelenburg position between exposures; (8) the first film is made three minutes after the injection, ureterograms and cystograms are taken as indicated and a compression binder with rubber bag inflation is used when gas is a problem.—*R. M. Harvey.*

Sargent, James C. Injuries of the kidney. *J. Urol.*, Feb., 1945, *53*, 381–386.

Urinary tract injuries are as a rule symptomless and may be overlooked for hours unless a urine specimen is obtained and examined in all cases where a kidney injury is a possibility. Gross hematuria demands investigation. Most cases of renal injury are better handled if put to bed and let alone. This is because of the shock usually associated with such injuries and the natural reparative power of the kidneys.

The author has found excretory urography following serious accidents valueless and often misleading for the following reasons: suppression of secretory function in an injured kidney, obscuring of kidney pelvis by blood clots and obscuring of renal detail by concomitant ileus. The author feels that the retrograde pyelogram should be made a routine in all accident cases in which there is a possibility of renal damage.

Comparatively good preservation of the contour of the kidney pelvis indicates non-operative treatment while complete disruption of the pelvis indicates an immediate nephrectomy. Illustrative cases are given.—*R. M. Harvey.*

Nelson, O. A. Arteriography in renal and abdominal conditions. *J. Urol.*, April, 1945, *53*, 521–533.

The pioneer in arteriography of the abdominal organs by aortic injection was dos Santos. Nelson's technique for this procedure is based on that of dos Santos. He uses a pressure apparatus with a No. 18 gauge needle, 12 cm. in length, a fast Potter-Bucky grid and a tube with a capacity of 500 ma. Eighty per cent sodium iodide is used as the medium. Needless to say, a knowledge of anatomy is a prerequisite to the aortic puncture. The patient is given 2 oz. of castor oil the afternoon before the examination and takes nothing but liquids from then until the time of the examination. Pentothal sodium is the anesthetic employed; a skin puncture is made under antiseptic precautions and the needle introduced just below the 12th rib 3 to 4 fingers' breadth to the left of the spinous process. The needle is directed downward and inward to the body of the 12th dorsal vertebra, is allowed to glide downward and over the lateral border of this body and advanced forward into the aorta. The injection is made under 1.5 atmospheres of pressure, after connecting the needle to the pressure apparatus.

An exposure is made immediately after the introduction of 6 to 8 cc. of medium. There are three hazards to this technical procedure; acute iodism, which was encountered in a mild form by the author in the early cases but has not occurred since the institution of the intravenous administration of 1,000 cc. of glucose (5 per cent) in normal salt solution immediately after returning the patient to bed; extra-aortic injection of the medium, this may cause some pain but the author does not feel it is a serious hazard; and extravasation of blood through the needle wound in the aorta. Nelson does not believe that leakage will occur from perforation of the aortic wall by a No. 18 gauge needle. He concludes that aortic puncture has no more hazard than a spinal puncture or cystoscopy. Five arteriograms made with this technique are presented with the author's interpretation.—*R. M. Harvey.*

Leadbetter, W. F., and Engster, H. C. Problem of renal lithiasis in convalescent patients. *J. Urol.*, Feb., 1945, *53*, 269–281.

The formation of calculi in patients long bedridden has been previously described. The more vigorous the life the patient has led prior to his incapacitation and the more complete the incapacitation, the more likely the development of renal calculi. These calculi are usually not recognized until activity of the patients is resumed unless infection supervenes.

The authors report a series of 14 cases in military life in which urinary calculi were discovered and presumed to have developed in completely immobilized patients during the period of their immobilization. These patients all had severe enough colic to require a urological consultation. The average time between immobilization and the development of urinary symptoms was seventy days. Inadequate fluid intake appears to be an important factor in the predisposition toward calculus formation.

The involvement was bilateral in 5 cases. The authors found the most useful single diagnostic procedure to be intravenous urography and this is advisable as the primary procedure. Calculi were found cystoscopically in only 4 cases. All cases exhibited hematuria.

As prophylactic measures for prevention of formation of calculi in bed-ridden patients the authors suggest adequate fluid intake, frequent turning of patients in bed, and avoidance of alkalinization of the urine by dilution through forced fluids.—*R. M. Harvey.*

Benjamin, J. A., and Boyd, H. L. Renal tuberculoma and tuberculous perinephric abscess. *J. Urol.*, Feb., 1945, *53*, 265–268.

The authors report the case of a twenty-nine year old white woman who had been in contact with a sister with active pulmonary tuberculosis. The patient was admitted to the hospital with complaints of weight loss, nausea and vomiting, frequent dysuria, dull ache in the left costophrenic angle, and fever. Tubercle bacilli were found in the smears of the urine but a roentgenogram of the chest was negative. A flat roentgenogram of the abdomen showed a fuzzy border of the left psoas muscle shadow and the medial border of the left kidney. Roentgenoscopic examination showed elevation of the left dome of the diaphragm with limited excursions.

Intravenous and retrograde pyelography

showed a crescentic pressure effect on the upper and middle calices of the left kidney suggesting cyst or tumor. An exploratory operation revealed a perinephric abscess with thick pus which showed acid fast organisms on smear. The kidney was removed at a later operation and showed a large caseous mass in the upper pole which had the pathological characteristics of a tuberculous lesion.—*R. M. Harvey.*

Flocks, R. H. The preventive treatment of calcium urolithiasis; important role of early and frequent roentgenographic examinations. *J. Urol.*, March, 1945, *53*, 427–439.

Conditions known to predispose toward stone formation include immobilization of the individual, paralysis of portions of the urinary tract, and trauma leading to obstruction and infection of the urinary tract. Frequent and early roentgenographic check-ups of the genitourinary tract are essential in the presence of any of these predisposing conditions.

The fundamental causes of calcium urolithiasis are hypercalcinuria, urinary stasis and urinary tract infections. To counteract the first cause, dilution of the urine by a large urinary output, a high vitamin A and B intake and an acid ash diet are essential. To counteract stasis frequent change of position of the patient, adequate drainage of the urinary tract by catheter and surgery and a large fluid output are essential. Infection is counteracted by the maintenance of a large fluid output, adequate drainage and chemotherapy.

In all patients in whom prolonged immobilization is required frequent roentgen examination should be made during the period of immobilization and then every three months for one year. The author's technique is to expose a plain film of the abdomen before and after injection of 20 cc. of diodrast. By use of this procedure routinely in immobilized patients irreparable damage to the kidneys from silent stones may be prevented. The author illustrates the importance of frequent roentgen check-up examinations with case examples, including reproduction of roentgenograms.—*R. M. Harvey.*

Donaldson, S. W. Extravesical lesions causing bladder neck obstruction. *Radiology*, Oct., 1944, *43*, 319–324.

The author has failed to find in the literature any study of obstruction of the neck of the bladder from extravesical causes. He therefore describes 5 such cases, giving roentgenograms showing the findings. Three were in women and 2 in men. The causes in the women were cervical fibroid, retroverted fibroid uterus and prolapsed fibroid uterus; those in the men were a chordoma of the sacrum protruding into the pelvis and a sarcoma of the left side of the bony pelvis. The causes of obstruction in the women therefore originated in the uterus and those in the men in the bones of the pelvis. Lesions of the lower bowel involving the rectum rarely cause obstruction of the neck of the bladder, probably because of natural mobility of the gut and of the pelvic fascia which serves as a barrier.

Extravesical lesions causing obstruction of the neck of the bladder are not hard to diagnose. They should be suspected if there is a pelvic mass and a negative cystogram. Extravesical tumors do not usually cause the rectal symptoms and venous stasis caused by retroperitoneal tumors. Careful pelvic and rectal examinations should be made and cystograms made. Blood urea determinations and kidney function tests should be performed. Early diagnosis should be made and treatment given in order to prevent irreparable damage to the kidney.—*Audrey G. Morgan.*

O'Conor, Vincent J., and Greenhill, J. P. Endometriosis of the bladder and ureter. *Surg., Gynec. & Obst.*, Feb., 1945, *80*, 113–119.

Endometriosis of the Bladder. Vesical endometriosis was first described by Judd in 1921 under the title "Adenomyomata presenting as a tumor of the bladder."

Incidence. It would appear that vesicle endometriosis is always secondary to pelvic endometriosis that has extended into the bladder from affected contiguous organs. It is presumed to be a relatively rare complication as indicated by the fact that only 58 authentic instances have been recorded in the literature.

Origin and Pathogenesis. Theories—(1) from inactive embryonic rests derived from remnants of the wolffian and muellerian ducts; (2) due to some hormonal or inflammatory stimulation, the endothelial cells of the peritoneum undergo metaplasia and assume the characteristics of endometrium; (3) origin from the endometrium and *always* from the endometrium.

Pathology. Invasion of the bladder by endometrial tissue may result in the formation of single or multiple tumors which vary in size

from a small pea-like excrescence in a bluish-black cyst several centimeters in diameter. The endometrial glands are scattered throughout a highly cellular stroma which is contiguous with the surrounding muscle bundles. The glands are composed of low to high columnar epithelium and in some areas the cilia of the epithelium may be discernible.

Symptoms and Signs. In 7 of the 58 patients studied the endometriosis was supposedly confined to the bladder and no intra-abdominal pathology was noted. Description of the mass varied from an almond to that of a small orange in size. When present the palpable tumor is usually tender and vaginal pressure upon it may reproduce the discomfort which caused the patient to seek relief.

Subjective bladder symptoms are variable. Some types of cystic disturbance was recorded in only two-thirds of these patients. The most constant symptom seems to be a sense of pressure or weighty discomfort in the vesicovaginal region. In some cases this was partially relieved by voiding but in others the pain was constant. Dysuria, frequency, and urgency are reported but no definite pattern of symptoms is described. Gross hematuria occurs much less frequently than one would expect. It was noted in less than one-third of the patients. The cyclic discomfort, which in the main was most apparent from two to fourteen days of each month, was not characterized by a definite menstrual association.

Cystoscopic Findings. The appearance may or may not be similar to the appearance of a "chocolate cyst" of the ovary. In many instances the mucosal changes have been reported as definitely cyclic in character. The mucous membrane is elevated and the tumor is usually markedly congested and edematous. The tumor is often larger during menstruation and less cystic during the intermenstruum.

Contributing Factors. Goodall considers endometriosis a product of our civilization, in that late marriages and still later conceptions are the rule. Ovaries afflicted with endometriosis are, in his opinion, unusually prolific, filled with ova, and with the product of developing matured and defective follicles.

Treatment. In the treatment of endometriosis, the problem is how best to effect a cure with the least amount of mutilation, not only physical but functional. For the inception of all types of endometriosis, the ovaries are essential organs and their continued function keeps up the activity of the disease. Removal of the ovaries, or the arrest of their function by natural or artificial means, usually causes an abrupt ending of the disease. Occasionally, removal of the ovaries does not arrest the disease.

In younger women, where one should make a sincere effort to preserve as much ovarian tissue as possible, localized excisions of involved areas should be practiced. Unfortunately, in these patients, recurrences are not uncommon and further surgery may be necessary to effect a permanent cure.

Roentgen irradiation of the ovaries or castration, in women approaching the menopause, should usually be followed by disappearance of the bladder involvement.

Large doses of androgen in a few reported instances seem to have been helpful in causing local tumor regression while awaiting the natural menopausal changes.

Endometriosis of the Ureter. A review of the available literature has revealed only one previously reported instance of intraureteral endometrioma. The authors report a case in a fifty year old widow in whom the diagnosis was "endometriosis of the ureter, with hydroureter and hydronephrotic atrophy of the kidney."—*Mary Frances Vastine.*

Pereira, Athayde. Câncer da prostata. (Cancer of the prostate. *Med. cir. pharm.*, March, 1944, pp. 140–156.

The author gives a general discussion of the problems involved in cancer of the prostate and an exhaustive review of the literature. In the years from 1926 to 1943 he himself has seen 95 cases of tumor of the prostate, 11 of which were carcinoma. Of these 10 were primary, 6 limited to the gland itself, 4 associated with adenoma and 1 a diffuse carcinosis with metastases. The other case was secondary from a cancer of the bladder.

The importance of preoperative care of the patient is emphasized. Among his 11 cases cystostomy was performed in 3, open hypogastric prostatectomy in 1, Lowsley's perineal prostatectomy in 1, radium treatment was given in 1 and roentgen therapy in 2. The others were not operated on. Eight of the patients are dead, 1 from late cardiopathy, 6 from late cachexia and 1 from late sepsis. Three still survive, 2 of those operated on and 1 of those not operated on. Of the 2 operated cases, 1 had a cystostomy and 1 a perineal prostatectomy.—*Audrey G. Morgan.*

NERVOUS SYSTEM

Echlin, Francis A., Ivie, Joseph McK., and Fine, Archie. Pantopaque myelography as an aid in the preoperative diagnosis of protruded intervertebral discs; preliminary report. *Surg., Gynec. & Obst.*, March, 1945, *80*, 257–260.

The new contrast medium pantopaque (ethyl iodophenylundecylate) has now made myelography a simpler and more justifiable procedure than it was in the past. The exact level of the lesion may be localized and operation limited to exploration at the precise interspace. This seems preferable to operative exposure at two levels, which is sometimes necessary before the protruded disc is found.

No untoward reactions are to be expected from the use of pantopaque if the agent is removed immediately following the examination. Removal can almost always be accomplished with ease by aspiration through a 20 gauge needle. If for any reason the agent is not removed it does not give rise to any greater reaction than does lipiodol, and in time is apparently larger, if not wholly, absorbed.

In the present study 36 pantopaque myelograms were done on patients with symptoms simulating those seen in the presence of a unilateral herniated nucleus pulposus. The results may be summarized as follows:

1. In 2 of these patients myelography indicated the presence of bilateral protrusion of a disc, which in 1 case was at two different levels. In 2 of the other patients, diffuse intradural pathology, probably arachnoiditis, was demonstrated.

2. It is believed that these findings illustrate the unreliability of a diagnosis based on clinical signs and symptoms alone. Clinical criteria indicated the presence of a unilateral herniated disc in each case and if relied upon would have failed to reveal the presence of a herniated disc on the opposite side or an intradural pathological lesion.

3. If errors in diagnosis are to be reduced, it is therefore advocated that, before a patient is subjected to operation, pantopaque myelography be carried out in the cases suspected of having a herniated nucleus pulposus in the lumbar region.—*Mary Frances Vastine.*

Eaglesham, D. C. Observations on opaque myelography of lumbar disc herniations. *Brit. J. Radiol.*, Nov., 1944, *17*, 343–348.

Herniated discs in the lumbar region can be diagnosed by the use of myelography, using lipiodol or pantopaque as an opaque substance. The herniations are generally at the level of the 4th or 5th lumbar or 1st sacral vertebrae and so the oil should be injected between the 2d and 3d or 3d and 4th lumbar vertebrae so that any deformity caused by the needle may be differentiated from the herniation. Three cubic centimeters of oil are adequate for the examination but 5 to 6 cc. are to be preferred. Four types of deformity of the myelogram are produced by the herniated disc: (1) indentation at the level of the disc space or slightly above or below it is the most common; (2) displacement of the oil column is infrequent; (3) there may be partial or complete block, partial block may cause an "hour-glass" image; (4) lack of filling of the nerve root sheaths. These types of deformity are illustrated by myelograms. Artefacts which cause difficulty in interpretation may be caused by indentation of the oil column by the lumbar needle if it is left in place during the examination, or by the extradural or subdural injection of oil.

If in addition to one or more of the above types of deformity there is thinning of the disc space, angular scoliosis at the level of the deformity, local osteohypertrophic lipping or loss of the normal lordosis, the evidence of herniation of the disc is greatly strengthened. —*Audrey G. Morgan.*

SKELETAL SYSTEM

Finkler, Rita S., Furst, Nathan J., and Klein, Michael. Clinical and roentgenological study of the effects of hormonal therapy on bone growth. *Radiology*, Oct., 1944, *43*, 346–357.

The effect of hormonal therapy on the growth of children has been studied at the Endocrine Clinic of the Beth Israel Hospital, Newark, N. J., for the past eight years. This article reports the results in 81 children, 18 of them treated with thyroid substance, 26 with anterior pituitary extract, 19 with chorionic gonadotropin and 18 with testosterone. Roentgenograms of the hands of children treated with these agents are given and tables showing the details of the results.

Thyroid treatment improved bone density and epiphyseal union. There was improvement in rate of growth, physical development and mental alertness. The best results were obtained in children who had had evidence of thryoid deficiency.

Treatment with anterior pituitary extract did not seem to bring about growth of bone or epiphyseal union but there was a general improvement in vitality, muscle tone and mental alertness in most of the children.

Chorionic gonadotropin treatment stimulated growth in length of the long bones but did not hasten epiphyseal union, bone maturation or density in the majority of cases. All the children showed an improvement in genital development, muscle tone, mental alertness and social adjustment. There was a loss of weight in most of the obese children.

Treatment with testosterone stimulated growth in length of the bones somewhat more than chorionic gonadotropin but did not hasten epiphyseal union. A moderate increase of bone density was noted in 3 out of 18 children. All the children showed improvement in gential development, muscle tone and self assurance and the majority gained weight. The rapid genital development made it necessary to interrupt the treatment except in 2 eunuchoid boys.

The hormone treatment brought about improvement in mental and emotional stability and improved psychological adjustment in children who were shy, self conscious or unsociable or who showed resentment against their parents or guardians or society in general. —*Audrey G. Morgan.*

Alderson, B. Roxby. Stress fractures of the first rib. *Brit. J. Radiol.*, Nov., 1944, *17*, 323–326.

In a series of 55,451 routine fluorographic examinations a condition was found in 35 subjects (0.63 per thousand) that was at first described as an anomaly of the first rib. It was always just proximal to the scalene tubercle; some of the cases showed an irregular transverse or oblique break in the continuity of the rib surrounded by a swelling which resembled callus. In others the swelling seemed to be fully formed bone. Three typical cases are described and illustrated with roentgenograms.

Only 5 of these individuals reported any symptoms. Two gave a history of sudden pain in the shoulder shortly after strenuous physical training, 2 reported direct trauma to the chest a few years before and the fifth said he had carried hundred weight bags of coal on the affected shoulder and had a sore shoulder for a week or two afterward.

These were all probably cases of so-called stress fracture or fracture by muscular action. Anyone may have pain or stiffness after unusually hard labor and usually no attention is paid to it unless the pain is severe. This lesion is found quite frequently among men in Service while it is rarely found in civilians. It is probably caused by compulsory physical training and drill.—*Audrey G. Morgan.*

Habbe, J. E., and Wright, H. H. X-ray evidence of old forgotten or previously undiagnosed fractures. *Radiology*, Dec., 1944, *43*, 531–547.

It would seem improbable that a patient would sustain a fracture without knowing that there had been some injury sufficient to warrant medical treatment. Such cases do occur, however, and in the bones of all parts of the body. In medicolegal cases the attorney for the defense frequently argues that a patient could not have had a fracture and ignored or forgotten it, but nevertheless if roentgen examination shows evidence of an old fracture such evidence should be accepted in spite of the patient's having forgotten the injury.

Old unrecognized or undiagnosed fractures of the bones of all parts of the body including such unlikely sites as fractures of the spine and pelvis, are described and illustrated with roentgenograms. Often the old fractures are discovered on examination for a fresh injury or incidentally in examination for some other condition. Possibly fractures of the ribs are the ones that are most commonly undiagnosed, untreated and finally forgotten. Very frequently these fractures do not cause any pain or dysfunction. Another fracture that often causes increasing pain and dysfunction later even though the original injury may have been forgotten is that of the carpal scaphoid or navicular bone. In every case of industrial injury of the wrist it would certainly help the examiner if one or two special views of the wrist were taken for the purpose of ruling out scaphoid fracture. The most useful positions are a posteroanterior oblique view with the radius away from the film and a direct posteroanterior projection with the wrist in acute dorsoflexion. —*Audrey G. Morgan.*